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The Eighth International Congress for Applied Chemistry.

On page 118 we print the official report of the preliminary meeting in which the organization of the Eighth International Congress was considered that is to be held in this country in 1912 with Prof. Edward W. Morley as honorary president and Dr. W. H. Nichols as acting president. It is a pleasure for this journal to endorse here fully the sentiment of chemical democracy expressed by Dr. Nichols at that meeting— that the central and vital point to be observed is that every chemist in the United States should feel that he is part of the Congress from the very creation of the organizing committee down through all the details of management to the very close of the Congress and that everything should be done which could in any way contribute to the realization of that thought. We endorse with equal sincerity the other leitmotiv of Dr. Nichols' suggestions "that quality and not quantity should count, that science should count against mere commercialism or ostentatious show." We recommend the official statement on page 118 to the earnest attention and consideration of all our chemical and metallurgical readers.

Ferrosilicon.

The extended article on the manufacture and transport of ferrosilicon, printed elsewhere in this issue, will be found to contain a considerable amount of useful and interesting information. But, we state frankly, that in publishing this information we do not intend or expect to encourage the erection of further ferrosilicon works at present. Up to a few years ago the higher grades of ferrosilicon, which require the use of the electric furnace, were almost exclusively made in Europe. The product came largely from that string of mountain electric-furnace plants, notably in southern France, which had originally been erected for calcium carbide manufacture, but had to look out for some other manufacture when the European carbide boom collapsed. During the last years the manufacture of ferrosilicon has been taken up in this country (which is really the pioneer country of the manufacture of other alloys in the electric furnace) and ferrosilicon is now being made by a large company with works in Niagara Falls, N. Y., and in Virginia, while another company makes metallic silicon in Niagara Falls, N. Y. Besides these there is a Canadian works for manufacture of ferrosilicon, operating in Welland, Ont., while a company which made ferrosilicon on a smaller scale in Lockport, N. Y., has recently discontinued operation due to the market conditions, which have continued to remain unsatisfactory in spite of the considerably increased duty placed on ferrosilicon by the new tariff. This is significant.

* * *

The simple explanation of the continued unsatisfactory ferrosilicon market is, of course, overproduction. When the

manufacture of high-grade ferrosilicon and other high-grade ferro-alloys in the electric furnace was taken up, it offered good profits. Steel manufacturers were also quick to realize the advantages of the high-grade electric furnace alloy, the use of which (in spite of its higher price compared with low-grade blast-furnace ferrosilicon) not only reduces very essentially the amount of undesired impurities (especially carbon) introduced with the alloy into the steel bath, but also has a higher energy content, heating the bath by the oxidation heat of silicon, instead of chilling it. But after all, the demand for high-grade ferrosilicon, as well as for other electric-furnace ferro-alloys, is a limited one in the nature of things. This is especially true, since the one ferro-alloy for which there is a really large market—ferro-manganese—is made almost exclusively in the blast furnace for good reasons which need no discussion at this place. It is not difficult to understand how overproduction came about with the prices of ferrosilicon practically cut in half. Now most of the French works are operating on a largely reduced scale. Of course, time will straighten out matters. The weakest producers will go to the wall and the fittest will survive. Then the new tariff may exert the effect to be expected.

* * *

While we do not know that any serious accidents have happened in this country on account of dangerous gases evolved from electric-furnace ferrosilicon, such accidents have happened in Europe and have attracted a great deal of attention in England. Concerning the nature of the gases and the possibilities of preventing such danger, the article in this issue contains much interesting information. So far the majority of the French manufacturers have agreed on making only certain grades, which are free from danger, while the British Government is likely to issue regulations on the transport of ferrosilicon. All these developments should also be interesting in this country, both for the producer and the consumer.

Cost of Power.

There still exists considerable confusion in the minds of many engineers as to the cost of developing power, especially water-power. Those who are interested in getting reliable and conservative figures on the basis of best modern American practice may be referred to a paper presented by Mr. Henry L. Doherty before the American Institute of Electrical Engineers on Dec. 16, 1909; in the discussion of this paper some very valuable figures on the cost of steam-power and water-power were given both by Mr. Calvert Townley and Dr. Cary T. Hutchinson. It is not our intention to go here into the details of those estimates, but we will simply give the following table of Dr. Hutchinson for the cost of energy in cents per kw-hour for steam and water-power plants, a medium-head hydroelectric generating and transmission plant being assumed in the latter case. These values are based on the assumption of a fixed annual charge of $13.60 per kilowatt, plus an output charge of 0.5 cent per kw-hour for the steam plant, and a fixed charge of $20 per kilowatt of demand on the water-power plant. As shown, at a high value of load factor the hydroelectric plant can show a much larger profit than the steam plant, while the profits decrease as the load factor becomes less. In the last column of the table is shown the price, at various load factors, at which energy from the hydroelectric plant must be sold in order to produce a profit of 6 per cent on the investment.

COST AND SELLING PRICE OF ENERGY PER KW-HOUR AT VARIOUS ANNUAL LOAD FACTORS.

Per cent. Load factor.	Cost of kw-hour in cents		Selling price, water power.
	Steam plant.	Water plant.	
15	1.54	1.52	2.44
25	1.12	0.91	1.46
33	0.97	0.69	1.10
40	0.89	0.57	0.92
50	0.81	0.46	0.73
60	0.76	0.38	0.61
75	0.71	0.31	0.49

* * *

The above figures, while apparently high, are undoubtedly correct for the average hydroelectric power and transmission plant. Under special conditions where the hydraulic development is easy and no transmission line is required they could be reduced. This will be true for many electrochemical plants which can be located right near the water-power. And the fact that electrochemical plants have a very high uniform load factor makes them ideal customers of the power-plant. Nevertheless, such prices as are reported from Norway—$4 or $5 per hp-year—can never be expected in this country under present conditions. For within the region over which power can be transmitted and distributed economically from the power plant, enough customers can always be found in this country to which power can be sold with greater profits. It is different in Norway. The question is not whether a power plant could generate power at such and such a very low cost, but whether it could sell it to electrochemical customers at so much less a price than it could get from others to whom the power would have to be transmitted over a distance. The margin between the Norwegian price of $4 or $5 per hp-year and the price which can be obtained from ordinary customers is so large that it would pay for quite an extended transmission and distribution system.

Electrolytic Amalgamation.

The notice of a patent for an electrolytic amalgamation process which appears in this issue under Current Metallurgical and Chemical Patents, gives us an opportunity to comment briefly on the probable rationale of this class of novel processes about which much has been heard in a somewhat general way from various parts of the West during the past few years. However the apparatus and the solution employed may differ, all these processes agree in making the amalgamation plate the cathode of an electrolytic cell; and the claim generally made for such processes is that in this way it is possible to recover on the amalgamated plate "floured gold," "rusted gold," and, in general, gold in a condition in which it cannot be recovered in ordinary amalgamation practice. There are three essentially different reasons why such an arrangement may be effective. In the first place, cathodic reduction, which always goes on at the mercury cathode surface, will reduce any oxides, etc., which may have formed on it; further, since in such processes a mercuric salt is generally used in solution, fresh metallic mercury is constantly being precipitated on the amalgamated plate. In this way the surface is always maintained in best condition ready to alloy with any particles of free gold which come in contact with it. In this respect nothing is changed in the principle of the ordinary amalgamation process; the current simply keeps the mercury plate automatically in perfect condition.

A second reason to which the effectiveness of electrolytic amalgamation may be assigned is suggested by some observations on gold telluride ores made by Dr. W. H. Walker and described by him in an American Electrochemical Society paper in 1903. He noticed that electrolytic methods working on this class of ore recover their values in greater part by direct cathodic reduction than they do by first dissolving the mineral in the electrolyte with subsequent precipitation of the gold on the cathode. Good contact with the cathode is, therefore, an essential requirement; for this provision is made in electrolytic amalgamation processes so that particles of ore of the class mentioned, when coming in contact with the cathode plate, are directly reduced by the current and the reduced gold then alloys with the mercury. A third possible effect which will vary with the nature of the solution used is the solution of gold particles in the electrolyte in form of a gold salt with subsequent precipitation of the gold on the cathode; in this respect the process would be like an electrocyanide or an electric chlorination process. From a practical standpoint the great saving in time, obtainable with electrolytic amalgamation, seems of prime importance. While these processes have attracted the attention of some able metallurgists, they have been developed in other places more or less by the rule of thumb. The general activity along these lines would indicate, however, that some concrete results have been obtained and that a distinct progress of lasting benefit to the metallurgical profession will be the ultimate outcome. Naturally, we should expect the new processes to be used on a commercial scale first for the treatment of such ores which offer special difficulties with present practice.

The Primitive Ideas of Some Connellsville Coke Operators.

At a meeting of the American Association for the Advancement of Science many years ago the late Dr. Samuel P. Langley suggested that while it was comfortable to conceive of the advancement of science as comparable with the progress of a large and well-disciplined army, a more truthful simile was that of a disorganized mob, bent on progress, but with groups constantly making sallies in this or that direction, so that at a given time the general trend of movement was hard to discern, although by observations taken at intervals a distinct forward movement of the whole mass could be noticed. A like simile might be applied to progress in the industrial arts. One invention or discovery waits upon another. Perhaps it is our reference just now to Dr. Langley which puts us in mind of flying machines; at any rate, we may observe that 20 years ago he clearly demonstrated the feasibility of mechanical flight, and, indeed, Lilienthal accomplished many "glides" before he met his death in 1889. Yet it was not until recently that perfect mechanical flight was accomplished. The success was really due to the development of a suitable internal combustion engine. Indeed, it is interesting to recall that one of Langley's troubles at one time in conducting his whirling table experiments was that the gas engine erected to drive it would not go.

* * *

Our mention of gas engines brings us to our subject. Twenty years ago efforts were made to introduce by-product coke-making into the United States, but these efforts were not successful. The value of the solid and liquid by-products was recognized, but it was doubted whether those values would be maintained in the face of heavy production. It was not admitted that the gas would have a great value. Naturally, it was not regarded as practicable to pipe it long distances to centers of population, when the much richer natural gas was available for the same purpose. The advent of the large gas engine, together with the means for economically converting the energy it produces into electrical energy, has multiplied by many times the commercial value of gas from by-product coking. The by-product coke oven has really awaited the perfection of means to make useful the gas which it was practically as well able to produce 20 years ago as it is to-day. Unlike the case of tar and ammonia, there is an unlimited market for gas for converting its energy into electrical energy.

* * *

In the past six months the coke operators of the Connellsville region have confessed an absolute ignorance of the developments in retort coking and the use of the by-products. The time was that Connellsville coke was regarded as the only really good blast-furnace fuel. Obsessed with the idea that perforce a much larger quantity of Connellsville coke would be demanded by the iron industry in 1910 than ever before, Connellsville coke operators last September and October pushed the value of their furnace coke to $3 a net ton at ovens, and then waited for the rush of customers. Through the growth of by-product and beehive coking in other fields the proportion of the total blast-furnace trade of the North, which depends upon Connellsville coke, has been reduced, and while the Connellsville operators waited for buyers to step to the counter, provision was made to use other cokes. There has been a tumble in Connellsville coke prices since the middle of January, and the industry now finds itself in the position of having much unsold production, but with no consumers, since their old ones are apparently provided with one coke or another.

* * *

In May of last year Connellsville furnace coke sold on contract for second half delivery at about $1.60 per net ton at ovens. There is no reason to suppose the price was unprofitable. An inspection of cost sheets indicates that at an average operation the cost of production, before the slight advance in wages in January of this year, was about $1.25 per ton, without depreciation and other fixed charges. The pushing of the price to $3 merely on the supposition that blast furnaces would have to pay the price or not make pig iron was a command to the industry to seek other fuel. When another fuel has been found, the consumer does not return to Connellsville. The customer is lost. Connellsville coke operators are anxious now to sell at much lower prices than those demanded late last year, but the business is gone. Report has it that they are now seeking to establish a "central selling agency" so as to maintain uniformly a high price for their coke. When they sell their coke at their own bare cost of production they are selling it for a greater price than it is worth, for they have produced it in the most wasteful and extravagant manner. They have failed utterly to realize that the day of by-product coking is fully arrived. They are exerting a tremendous pressure toward the adoption of modern methods, but they are killing their own business and writing an enormous depreciation upon their coal reserves.

Eighth International Congress of Applied Chemistry.

On the evening of Feb. 3, 1910, an informal gathering took place at which there were present among others most of those to whom had been delegated the task of providing for the creation of an organization for the Eighth International Congress of Applied Chemistry, by the London Congress last June; a representative of the Association of Manufacturing Chemists, the American Chemical Society, the American Electrochemical Society, and the Society of Chemical Industry were each also present at this informal meeting.

The consensus of opinion was that the greatest success could be expected only if the most effective system and mode of organization could be had, and if each and every chemist in the United States could be made to feel that he himself directly or indirectly through his professional, business or educational affiliations, had a personal share of responsibility in the conduct and management of the Congress from its very start and to its very end.

This was regarded as the proper and correct guide in proposing any plans or schemes of organization.

The Eighth Congress is to convene in 1912, with Prof. Edward W. Morley as honorary president and Dr. W. H. Nichols as acting president, at a time and place to be determined by the organization of this Congress. The most important part of the Congress, in fact that by which its value and real success will be measured, is the amount of original matter, both scientific and technical, which it will be able to present to its members.

To attain this end fully every chemist in America who has or may have any original matter to present to this Congress should begin without delay to prepare such matter, and have it in shape so that it may be presented to the Congress in ample time for proper printing, classification, and distribution to members and the technical and scientific press.

The Congress, being held in the United States, will with a great deal of right and naturally look to a very good showing from the chemists of the United States, and every chemist in this country, which is to be host to our foreign colleagues, should constitute himself a committee of one to get from himself, or from his friends, as much scientifically or technically valuable material as possible so that the proceedings and publications of the Eighth Congress may correctly reflect the true mental attitude of the chemists of the United States toward their profession, both as a pure science and as a part of the industrial activities of this country.

It is the hope that the Program Committee will be able to begin its activities effectively before the close of 1910, but in the meantime it behooves every chemist in the United States actively and energetically to consider how and in what way he can best contribute to the success of this Congress, and particularly in the direction of papers and communications to the Congress embodying the advance in this field since June, 1909, the date of the last Congress.

At a meeting to be held in April or May, 1910, by those charged with the duty of providing suitable organization for the Eighth Congress, some definite action as to such organization may be looked for. Those who have that responsibility are making every effort to get as many suggestions as to divisions of organization, mode or organizing, and membership of the organization as possible. Every one interested in having this organization on as broad foundation as possible is earnestly invited to present any suggestions that may be helpful in that direction in writing by the middle of April, 1910, so that all these suggestions may be properly classified and collated and put in condition for most thorough consideration before the meeting above referred to actually takes place.

Such communications may be addressed to the temporary secretary, Dr. B. C. Hesse, 90 William Street, New York City.

Bureau of Standards' Analyzed Samples.

The Bureau of Standards, Washington, D. C., is ready to distribute Bessemer steels with 0.6 and 0.8 carbon and an iron C to replace that originally prepared by the American Foundrymen's Association. The new C has the following composition: Total C, 2.78; graphite, 2.22; Si, 1.84; Ti, 0.074; P, 0.192; S by oxid, 0.0354; S by evol., 0.0335; Mn, 0.744.

A new iron B was found to need remixing and partial analysis. It is hoped that the sample will be ready to distribute by the time this notice appears in print.

A vanadium steel and an ore of manganese await the reconciling of differences in the analytical results reported.

Three Lake Superior iron ores are undergoing analysis; one to serve as a standard for iron, phosphorus and silicon; the second for aluminium, calcium and magnesium; and the third for manganese.

Standardization of Bullion and Assay Values.

The Sectional Committee B for the standardization of bullion and assay values of the Institution of Mining and Metallurgy was formed for the purpose of recommending rules which shall, as far as possible, be followed by assayers, metallurgists and mining men in reporting the results of assays and of metallurgical, dressing and other tests of which assays form an essential part, so that ambiguity shall be avoided and the possibility of misinterpretation or misuse of reports shall be minimized. The committee has now submitted to the council of the Institution the following report, which is now to be considered, before being finally adopted.

Reports of assay results, extraction tests, metallurgical and ore-dressing trials, etc., are sometimes so worded as to permit a wrong interpretation, and the committee urges the necessity for definite statements as to the nature and condition of the sample as assayed, and, where advisable, an indication of the method of assay. Thus, in the case of such metals as copper, tin, lead, antimony, etc., where both "wet" and "dry" methods of assay are in use, results should be reported as obtained by "fire" asay or by "wet" assay, with further details as to method, if adjudged advisable. Similarly, it should be stated whether the sample was assayed in the condition in which it was received, or "air-dried" or dried at —° C.

In reporting that an assay for such a constituent as tin, arsenic, tungstic acid, etc., corresponds to so much "black tin," "white arsenic," "wolfram" or other recognized saleable product, the report should give the assay result for such constituent, together with a definite statement as to the figures used in calculating such saleable product. Thus, an assay showing 1 per cent of metallic tin might be reported as 1 per cent of metallic tin, equivalent, if all could be extracted as such, to 1.5 per cent of "black tin" containing 66.6 per cent (or two-thirds) of its weight of metallic tin. Similarly, in reporting results, where assay values might be mistaken as representing available produce, it should be stated that such are merely "gross" assay values, a statement or estimate of the actual "commercial" values being added whenever possible.

In such matters as ore-dressing, ore-treating processes, furnace work, etc., where so much depends on the way in which results are reported, on the nature of the sample and on the method of taking it and its relation to other samples, the committee emphasizes the necessity for careful phraseology and for the inclusion of exact data, as also the necessity for care in preparing, describing, labeling, sealing and otherwise ensuring the correctness and authenticity of samples submitted for tests or assays.

The bullion and assay values committee submit the following recommendations for adoption by the Institution:

(1) Assay reports shall state the exact condition of the sample as to dryness when assayed.

(2) Assay values of gold and silver ores and products shall

be represented in pennyweights and decimals or in ounces and decimals, and not in oz., dwts. and grains. They shall be expressed in terms of fine gold and fine silver, respectively, not as "bullion."

(3) Assay values of alluvials shall be reported in grains and decimals of a grain of "fine"gold, or in pence (at 2d. per grain of "fine" gold), or cents per cubic yard.

It is recommended that, in the absence of specific information, 1 cu. yd. of ordinary alluvial, excluding boulders, be taken as equivalent to 3000 lb. (1½ short tons).

(4) In reporting assay values of cyanide and other solutions, the results shall be given in parts by weight in a stated volume of the solution. (In the case of cyanide solutions, the use of the "fluid ton of 32 cu. ft." is recommended. It closely approximates to 2000 lb. and is in common use.)

(5) When it is necessary to state or estimate the money value of an ore, etc. (other than of gold), it shall be accompanied by the assay value, and the basis on which the former has been calculated from the latter shall be stated.

(6) Laboratory sieving tests shall be made with the I.M.M. standard sieves, or, when other sieves are used, the widths of the apertures shall be stated.

The report is signed by G. T. Holloway as chairman of the committee.

With the above recommendations, if approved, will be included the following, which have already been adopted on the recommendation of the weights and measures sectional committee:

(*a*) The word "ton" shall represent a weight of 2000 lb. avoirdupois (2,166.6 oz. troy). (It is advisable to abandon the use of the terms hundredweights and quarters, and to express fractions of a ton in pounds or in decimals of a ton.)

(*b*) The word "gallon" shall represent the Imperial gallon measure of 10 lb. of water.

(*c*) Temperatures shall be expressed in degrees Centigrade.

(*d*) Returns of gold and silver shall be expressed in terms of fine gold and fine silver, respectively, not as "bullion."

(*e*) Gold contents of ores, etc., determined by assay, shall be expressed in money values as well as in weights; and in this connection the value shall be taken (as a convenient constant) at 85 shillings, or $20.67 United States currency, per troy ounce of fine gold.

The Iron and Steel Market.

February has been a dull month in the market, demand being light all along the line, while prices have definitely receded on pig iron and have shown weakness on a few finished steel products. The market failed to bear out any of the prognostications. In December, when new buying was light by comparison with the six preceding months, opinion was divided as to whether the market would show a decided improvement early in the new year or would merely hold its own. It has done neither; it has lost ground, and has lost more in February than in January.

The American iron trade suffers from a delusion that the hanging of new calendars upon the walls of business offices is an incentive to the placing of orders. Time and again it has staked its all upon the improved business which "the new year" would bring, and as often it has been disappointed. In the late months of 1908 there was a well-defined boom and in all quarters the belief was expressed that this small boom was but the precursor to the big one which the new year would bring, but the new year brought a crash in prices as well. Even when the remarkable period of activity of 1905-06-07 was being ushered in there occurred the delusion of the calendar, for the improvement which occurred in the late months of 1904 was regarded as but the forerunner of a still greater improvement to occur early in 1905, whereas pig iron lost ground almost steadily during the first seven months of that year and steel products would probably have done the same had they not been well held by a trade understanding.

The feature of the trade revival in the second half of 1909 was the uneven distribution of the improvement; merchant steel bars constituted the market leader, carrying with them plates and shapes; wire products did well, and so did sheets and tin plates, while merchant pipe was heavy, the buying being largely because of the low price, jobbers buying for fear there would be an advance and mills fearing to advance prices lest buying should be discouraged. Rails showed almost no movement.

Students of the psychology of market movements may be interested in the influences produced by the different finished steel products being more or less completely under the influence of different systems of selling developed by the respective subsidiaries of the United States Steel Corporation. There are temperamental differences between the managements of the different subsidiaries. The common ground upon which they meet is that of their reports to headquarters of results achieved in tonnage booked. It is not impossible that in the efforts of given subsidiaries to show results comparing favorably with those of other subsidiaries the importance of immediate results is magnified and the importance of providing for the future is minimized. Without attempting to pursue the query at this time, it may be remarked that the result of the operations of the last seven or eight months of 1909 was to leave the different branches of the finished steel trade with orders booked for quite varying distances ahead. Steel bars were sold for nearly six months ahead, plates and shapes for perhaps four months ahead, and pipe and wire for scarcely any distance at all ahead, while jobbers in these two latter lines were more than comfortably stocked. Both by the necessity of physical conditions, since these products are all made from the same semifinished material, and by the temperament of purchasers, who regard the iron and steel trade as an entity and not as a chance group of unrelated elements, the strength of the market as a whole is largely in relation to the strength of its weakest element. Consumers of steel bars are not likely to be enthusiastic buyers for far forward delivery when they observe that prices of wire products are being cut and production is perhaps being curtailed.

Pig Iron.

The spectacular buying of Bessemer pig iron from June to October of last year advanced the market rapidly from $14.50, valley, to $19, a price which was first done Oct. 12, there being altogether more than 100,000 tons sold at that figure. It is an open secret that the large independent steel interests buy Bessemer iron at such times partly because they really expect to need it, partly because they may need it, and partly because such purchases help to improve the market for their finished products. Many contracts for billets and finished steel products are on a scale basis, the price determined by the average selling price of Bessemer pig iron.

It was expected that Bessemer pig iron would draw other grades of pig iron along in the advance, but basic pig iron halted at $17.25, leaving a spread of $1.75 between the grades. In 1905-06 the average spread was about 25 cents and in 1907-08, when Bessemer ores were 25 cents per ton higher relative to non-Bessemer ores, than in the preceding years, the average was about 75 cents. Expectations that basic pig would advance to reduce the spread were disappointed, for in November basic receded to $17 and in December a slight further recession occurred. Toward the close of January it developed that basic could be bought at $16.50, leaving the position of Bessemer at $19 altogether untenable.

There was danger of a break and to crystallize sentiment into a moderate decline the United States Steel Corporation, early in February, bought 40,000 tons at $18, valley, leaving the trade under the impression that upon occasion further purchases might be made. The Bessemer market rests at this. Basic, openly offered at $16.50, valley, has been quietly offered

at $16, and two or three forced sales have been made at slightly lower prices, so that the situation is again involved. In foundry pig iron there have been recessions in nearly all districts.

Virginia furnaces came down to $15 at the furnace for No. 2 plain, silicon 2.00 to 2.50 per cent, and 2500 tons of Southern iron were sold on the basis of $13, Birmingham. In eastern Pennsylvania there were slight recessions. The valley market dropped to $16.25. The total decline from the top point in November has been approximately $2 at Birmingham, $1 in Virginia, 50 cents in eastern Pennsylvania, and $1 in the valley market.

Steel.

The supply of unfinished steel has increased in all districts. Chicago producers have become sellers of forging and rolling billets, having been out of the market for several months. In Pittsburgh and the Central West deliveries of billets and sheet bars have become very good, to such an extent that some consumers have requested shipments postponed. Prices have not openly yielded, but it is improbable that any large tonnages could be sold except at material concessions. There is no demand, consumers being amply covered by contracts. Nominal prices are approximately as follows, f.o.b. maker's mill, Pittsburgh or Youngstown:

Bessemer billets, $27 to $27.50; open-hearth billets, $27.50 to $28; sheet bars, $28.50 to $29; rods, $33.

Strictly new buying of finished steel products has been light. Specifications on old contracts have been fairly good. The steel-car shops are running practically full, booked for four to six months. The fabricating shops are about equally well filled.

The plate and shape mills in the Pittsburgh and in the Chicago districts are comfortable taken care of until about June 1; the Eastern mills have already begun to make concessions of $1 a ton. Demand for ordinary sheets has become light, while specialties are still in demand, particularly electrical and stamping sheets.

Some sheet mills which were extremely optimistic last fall and book little business have not much work in sight, while others are comfortably filled.

Early in January steel bars were quoted by all interests at $1.50, base, the December market having been $1.45 on contract and $1.50 for small, prompt lots. The former position has been resumed, the market being $1.45 on contracts, but it is a position whether this constitutes an actual recession, the minimum of $1.50 not having been absolutely established.

Regular prices, at Pittsburgh, except where otherwise noted, stand:

Standard steel rails, $28 for Bessemer; $30 for open-hearth, f.o.b. mill except Colorado.

Plates, $1.55 for tank quality, ¼ in. and heavier.

Shapes, $1.55 for I-beams and channels, 15 in. and under, zees and angles, 2 x 3 and larger.

Steel bars, $1.45 to $1.50, base.

Iron bars, $1.65 to $1.70, Pittsburgh; $1.55 to $1.60, Philadelphia; $1.55 to $1.60, Chicago; $1.50 to $1.55, St. Louis.

Wire nails, $1.85, base; plain wire, $1.65; galvanized barb wire, $2.15.

Black sheets, 28 gage, $2.40; galvanized, $3.50; blue annealed, 10 gage, $1.75 to $1.85; painted corrugated roofing, $1.70 per square; galvanized, $3.

Tin plates, $3.60 for 100-lb. cokes.

CORRESPONDENCE

Iron-Copper Alloys.

To the Editor of Metallurgical and Chemical Engineering:

Sir:—We note with interest Mr. George W. Sargent's comments on the paper "Physical Properties of the Iron-Copper Alloys." We are realizing full well the limitations of data obtained from experiments conducted on a laboratory scale and under special conditions of working, and it is, therefore, of interest and of advantage to have the opinions of practicing metallurgists regarding the probability of repetition of interesting results from operations conducted on an industrial scale.

We can appreciate Mr. Sargent's statement concerning a lack of harmony between the preface of our paper and the actual work done, and that the two together give an erroneous impression. This is caused, no doubt, by the fact that the article in *Electrochemical and Metallurgical Industry* was only an abstract of the paper presented at the meeting of the American Electrochemical Society. While the report of our experimental work was reprinted practically in full, the introductory matter was necessarily very much condensed.

Our paper points out that the first impressions regarding the presence of copper in steels were that it was decidedly deleterious; that later work showed that small amounts did not have the pronounced detrimental effects usually attributed to copper.

Finally, we quote the experimental data of other investigators, and corroborating our results, tending to the conclusions that additions of copper up to 4 per cent were accompanied by material increase in the tensile strength of the steel.

Mr. Sargent believes that red shortness would be the general result of copper additions, especially in the familiar steel-making processes, due to the oxidizing reactions and the consequent formation of oxides of copper. We do not believe that this contention is supported by chemical facts or metallurgical experience.

These facts are:

Iron will oxidize to ferrous oxide more readily than copper will to cuprous oxide.

Either iron or copper oxide will be reduced by carbon, manganese, aluminium, or silicon, the common deoxidizing agents of steel-making.

Consequently, we should expect that if oxidation of the bath were carried to the extent of formation of dissolved oxides, ferrous oxide would be the first to form, and brittleness would result whether copper were present or not. Again, it is to be expected that the customary additions would have an even greater effect in reducing any copper oxides than they now have on the oxides of iron.

Experience in the metallurgy of copper supports this view. As reverberatory refining of copper is conducted, the iron is oxidized and scorified with the additions of sand. To quote from Schnabel's "Handbook of Metallurgy," Vol 1, page 237: "The separation of these elements (impurities, including iron, lead, zinc, etc.) can be brought about by oxidizing fusion of the coarse copper." "By oxidizing fusion of coarse copper, its foreign constituents (with the exception of the precious metals) can be oxidized (because their affinity for oxygen is greater than that of copper) and slagged off."

It seems likely, as was intimated in our paper, that the unfavorable influences are the effect of increase of carbon on the structural relations of copper and iron, and the affinity of copper for any sulphur which might be present, with the formation of sulphide of copper and its incorporation in the body of the steel.

Chemical Engineering Laboratories, James Aston.
University of Wisconsin.

The Patent Treaty With Germany.

To the Editor of Metallurgical and Chemical Engineering:

Sir:—Enclosed please find a translation of a very important recent decision* of the German Reichsgericht (Supreme Court). It refers to the recently concluded patent treaty between the United States and Germany.

*An abstract of this is given elsewhere in this issue, in the article entitled "A Reichsgericht Decision on the Scope of the Patent Treaty between the United States and Germany."—Ed.

The Imperial Court interprets this patent treaty in a most liberal way and comes to a conclusion which is causing general indignation among industrial circles in Germany.

The patent treaty in question was concluded because the Committee on Patents of the House of Representatives threatened to introduce a working clause similar to the one of the British and German law into the American Patent law. In order to free the citizens of both countries from the burden of such a working clause the treaty was concluded.

Now, this working clause has not been introduced into the United States Patent law, and there does not exist any reason for such a patent treaty between the countries.

Meanwhile the treaty is exerting its influence in litigations under the German patent law to the greatest detriment—as many interested parties claim—of the industries of the German Empire, and there is a strong agitation to induce the Government to cancel the treaty.

It is pointed out that Great Britain, which peremptorily refused to conclude a similar treaty with the United States, has now the laugh on Germany.

To refer back to the decision, the court decrees that a German owning a German patent is forced to work his invention either in Germany or the United States, while an American owning a German patent needs not work his invention either in Germany or the United States because the country of his nationality does not enforce the working clause.

Consequently, a German owning patents may avoid the working clause by assigning his patent to an American.

MANUFACTURER.

Silundum.

To the Editor of Metallurgical and Chemical Engineering:

SIR:—Professor Tucker's excellent paper on "Silundum," which is in full accordance with the experience obtained in the commercial production of said material, has caused a controversy between Messrs. E. G. Acheson and F Bölling, as well as your editorial remarks in your last issue.

Leaving aside the question of the priority I first only beg to state one fact which possibly might elucidate the matter, and secondly call your attention to the rôle of an element which hitherto has been overlooked by most of the experimenters though often contained in carbon-silicon compounds:

(1) Dr. Acheson says that the heating of carbon, silicon and oxygen may either result in the formation of graphite, silicon or carborundum, or of a compound of all the three elements. No doubt about this. But there are only a relatively small number of analyses existing of siloxicon, and so far it does not seem to be a definite chemical individual. We find in many other cases, too, that a practically useful material such as siloxicon need not possess a uniform chemical composition. There is no reason why it should not be possible to combine the first two elements also in such a way as to form a product of variable chemical formulas. On the contrary, the presence of dissolved carbon and silicon in many metals makes it probable that an alloy of these two elements exists, and that is what silundum seems to be and what further scientific investigation is expected to affirm. It may have spontaneously been formed in some furnaces long ago, yet it had not been discovered.

(2) Among the earliest literature about the reactions of carbon and silicon at high temperatures we find compounds of these elements with nitrogen described. As the coke employed in the carborundum furnace contains nitrogen, there is no doubt that this element, preferably reacting at high temperatures, influences the product of the furnace in a certain way; about the character of this influence we know even less than about that on iron and steel. Nitrogen is found in carborundum as well as in silundum, as stated on another occasion (*Zeitschrift für Elektrochemie*, 1909, p. 727), and I regret that industrial work did not leave me the time to pay the necessary attention to this question.* But if once the binary silicon-carbon diagram will have been devised the further evolution of the Acheson diagram must necessarily take notice of the nitrogen as well as of the oxygen.

CHICAGO, ILL. R. AMBERG.

*The so-called oxygen contents of siloxicon is mostly given as the difference between the total and the silicon and carbon, analytically determined.

The Trust from the Standpoint of an Engineer.

To the Editor of Metallurgical and Chemical Engineering:

SIR:—Your journal has on its editorial page alluded so often to the trust question, both in its general aspects and particularly to the metallurgical trusts, that possibly my views will interest your readers, for I have had business relations with several of the large trusts, and thus have first-hand knowledge. Lately I have read a very remarkable exposition of the economics of the trust question by the Hon. Bourke Cockran in his brief for the American Tobacco Company before the Supreme Court of the United States. This elucidates the theory of monopolies from the standpoint of English common law. My reasoning of the case is along quite different lines, but the end product is in each case the same. Let me say that I hold no brief for the American Tobacco Company, as I usually insist on smoking non-trust cigars.

In the first place, let it be stated that by a trust is meant a large corporation seeking to dominate the market for any one commodity and actually possessing preponderant trade influence in that market. This is the usual definition.

Now the trust is but a natural outgrowth of industrial evolution. We know that evolution is that process by which things grow through countless small processes of differentiations and integrations from the tiny homogeneous units to the large heterogeneous unit. The great contribution of the nineteenth century to the philosophy of the ages was the formulation by Darwin of that doctrine in the biological world and its application by Herbert Spencer to all branches of science. So it is just natural to point to the United States Steel Corporation for instance, as the product of a perfectly natural industrial evolutionary process. Demagogues may rail at it, at Mr. Carnegie and at Mr. Morgan. But facts are facts. We see the United States Steel Corporation pursuing the even tenor of its way (not, of course, the market value of its stock) and we can only admit that it is a product of the age.

As no one but a simpleton will deny the above argument that the "trusts" are the logical outcome of the natural evolution of industrialism, let us inquire why it should exist in the light of the evolutionary theory. Naturally, it exists because the fittest survive. This is simply tautology. So let us ask why it should survive, or, better, why one trust survives and another goes to the wall. First of all, it can be stated that it exists because the weight of public opinion is on its side. For does anyone suppose that if the mass of people in this country believe all the things said about the Standard Oil Company that it would survive a day? I doubt whether legislative enactments would be used at all, but it would seem probable that physical violence would be rightly used. No! the average of public opinion is that the Standard Oil Company, though far from perfect, is, on the whole, serving a beneficent purpose in the United States. It undoubtedly took rebates, but you could sweep this wide country and if you can show me 100 small country cross-road grocers that would refuse to accept a reduction of 50 cents per barrel of flour if they handled exclusively one brand, I misjudge human nature. It is just human nature to trade with your friends. And rebating, so common once, is similar to the practice of giving a special favor to your friends.

Now, the trust stands in spite of adverse public opinion of the discontented minority. Why does it sell its goods to this American people, who, though easily fooled for a short time, do

not stay fooled long? Obviously because on the average it produces and sells its goods on quality and price. Against this it may be argued that the Steel Corporation is charging a high price for rails and is making large profits at prices higher than prevalent in Europe. But, without the evidence, let me assume as a fact that steel rails can be produced at a factory cost of $15. This figure is, to the best of my knowledge, about correct. Why, then, do not outside companies step in and erect large plants if profit is so large? There is a multiplicity of causes as in any phenomenon. But the chief reason, in my opinion is that the risk of the business, the value to the community of ore in the ground and other charges reduce the net return on the investment to about 15 per cent. Now, there are so many kinds of smaller manufacturing companies doing a business of from $100,000 to $1,000,000 per year in this country at a profit of greater than 15 per cent that there is not present in the United States the kind of capital that cares to go into the rail business when, for example, the automobile business exists.

If the American people want rails sold at less than $28 per ton, let it subject, by removing the tariff, the rail manufacturers to the competition of Germany, where manufacturing profits are much less.

It can be laid down as a fact that in this country, therefore, there is always plenty of competition if the profits are large enough. As Mr. Cockran well says, "competition may be potential or active."

Now, any trust may fall (and great will be the fall thereof), provided it is managed in an non-progressive, unintelligent and crassly selfish manner. And conversely, a trust will succeed provided it is managed in an up-to-date, intelligent manner and in a spirit of enlightened self-interest. And, furthermore, its degree of success depends upon the measure of intelligence of its management. The same is true of a railroad or any concern of any kind at all. Efficiency spells success. Somehow or other, intelligence seems to win in this world in the long run. In short, intelligently managed concerns, large or small succeed. If the trust makes mistakes, its mistakes are just so much the more costly as the trust is big. And some one of the independents, the one who uses the best intelligently directed head work, will take the first place in the hegemony.

It can be laid down as a fact that purely economic laws govern the rise and period of life and degree of usefulness of these large corporations. Purely economic laws govern their action. And the laws of economics grind slowly, but they grind exceeding fine. This is what history teaches from the days of Adam Smith down.

Comparisons are invidious, and it would be idle for me to draw comparisons to any great extent and, besides, a breach of confidence. But it is a matter of common knowledge that the United States Steel Corporation, by a policy of persuasion rather than of coercion, in 1906 and the first part of 1907 did restrain steel prices from going to extravagant high levels, and in the last three months of 1907 did hold prices from going to the everlasting bow-wows. In 1908 the prices were allowed to subside gradually, but the retreat was an orderly one, so that to-day of all the metal markets the iron and steel market is alone in a healthy and stable condition.

The copper market in 1907 was a runaway one. Consumers were in a panic and lake copper sold as high as 27 cents. This was due, first of all, to natural causes, such as shortage of coal and labor in the mining centers, but, second, to a more or less concerted action on the part of the producers by exaggerating actual conditions. So the copper producers danced and have been paying the piper for the past year. Undoubtedly there was no actual conspiracy on the part of the producers, but action may be concerted, though entirely tacit and even unconscious.

But the steel business was managed intelligently for the interests of the entire business and the copper business was handled in a spirit of narrow selfishness. We see that this was a boomerang.

And if the Supreme Court of the United States construes the Sherman law so that the policy of keeping prices stable and reasonable is a crime, my great respect for that body will be lessened.

It is thus seen that the policy of a trust should be to conserve the best interests of the trade and that its own interests are so best served. Stable markets are better for the consumer than unstable markets, even when the average price of the latter is somewhat lower than the average price of the former.

The trusts can act efficiently in other ways. For example, unprofitable plants can be shut down. The highest salaries can be paid to business and technical talent. General expenses or the amount paid for intelligence and diffusing it, can be large absolutely and still be a small percentage of the total cost of production. Purchases can be made in large volume, and hence low. Plants can be remodeled and new processes put in, as for example, the Héroult electric steel furnace by the Steel Corporation, and undoubtedly this is the line where commercial inertia inhibits progression. Laborers can be given steady employment, and hence are much more efficient. Profit-sharing makes them partners in the concern. Money can be borrowed much more cheaply and in large amounts.

Two large trusts are typical and illustrative by reason of the peculiar nature of their business of the general excellence that trusts can have. These are Swift & Company, "the meat trust," and the United Fruit Company, the "banana trust." The former does a business of $300,000,000, in round figures, per year on a 3 per cent margin. The latter makes a marginal profit of 10 cents per bunch containing over 150 bananas. Let any business man deny that these margins are excessive. The retail margin of the small butcher and Italian who peddles bananas is from 6 to 10 times the margin of the large wholesaler. Only on one assumption can these two concerns be harmful to the body economic, and that is that the officials are stealing flagrantly from the stockholders and falsifying the books. The high personal standard of honor among the directors of these two companies precludes this idea and dismisses the assumption as absurd.

For my own part I cannot but admit that (1) the badly managed trust goes to the wall quickly; (2) the well-managed trust helps everyone but those who have become suddenly rich by its incorporation and spend all their money and all their time in riotous living. For the idle and inefficient, who lose their jobs or their property by its competition, have at least the solace of kicking, and in their own minds attributing their misfortunes to the machinations of others. They are, indeed, then happy in their misery.

Finally, let me state that Mr. Cockran's argument before the Supreme Court is that any company which has increased its production and kept its prices from advancing while general prices have advanced is not restricting trade. For increase of production is increase of trade. Nor is restriction of intelligent competition restriction of trade. In short, restraint of trade is one thing and restrain of competition is another thing. Mr. Cockran further points out that if trade is restrained by conspiracy or acts of violence it is certainly against the common law of our country and England, and, hence, punishable by fine or imprisonment.

In short, Judge Parker was right in 1904 when he said that the trust question could be solved by the application of common law. Possibly ex-President Roosevelt was also right in his solemn affirmation that a good trust is good for the country and that a bad trust is bad for the country. But in the modern schools of psychology the theory of value is prevalent, and to evaluate the good in men, women and things is an eternal problem. It were far better for the American people to stick to the common law, not to try to legislate morals into themselves, and ever to seek to evaluate the things as they see them in the light of things as they are.

Hartford, Conn. Woolsey McA. Johnson.

Temperature Conversion Table.

Through the courtesy of Dr. LEONARD WALDO, consulting engineer, of 49 Wall Street, New York City, we are enabled to reproduce herewith his very convenient Centigrade and Fahrenheit temperature conversion table.

Dr. Waldo's table is self-explanatory. It will be found to be based on an arrangement well known from logarithmic tables, but novel for the conversion of temperatures. Besides

C°	0	10	20	30	40	50	60	70	80	90
	F	F	F	F	F	F	F	F	F	F
−200	−328	−346	−364	−382	−400	−418	−436	−454		
−100	−148	−166	−184	−202	−220	−238	−256	−274	−292	−310
−0	+32	+14	−4	−22	−40	−58	−76	−94	−112	−130
0	32	50	68	86	104	122	140	158	176	194
100	212	230	248	266	284	302	320	338	356	374
200	392	410	428	446	464	482	500	518	536	554
300	572	590	608	626	644	662	680	698	716	734
400	752	770	788	806	824	842	860	878	896	914
500	932	950	968	986	1004	1022	1040	1058	1076	1094
600	1112	1130	1148	1166	1184	1202	1220	1238	1256	1274
700	1292	1310	1328	1346	1364	1382	1400	1418	1436	1454
800	1472	1490	1508	1526	1544	1562	1580	1598	1616	1634
900	1652	1670	1688	1706	1724	1742	1760	1778	1796	1814
1000	1832	1850	1868	1886	1904	1922	1940	1958	1976	1994
1100	2012	2030	2048	2066	2084	2102	2120	2138	2156	2174
1200	2192	2210	2228	2246	2264	2282	2300	2318	2336	2354
1300	2372	2390	2408	2426	2444	2462	2480	2498	2516	2534
1400	2552	2570	2588	2606	2624	2642	2660	2678	2696	2714
1500	2732	2750	2768	2786	2804	2822	2840	2858	2876	2894
1600	2912	2930	2948	2966	2984	3002	3020	3038	3056	3074
1700	3092	3110	3128	3146	3164	3182	3200	3218	3236	3254
1800	3272	3290	3308	3326	3344	3362	3380	3398	3416	3434
1900	3452	3470	3488	3506	3524	3542	3560	3578	3596	3614
2000	3632	3650	3668	3686	3704	3722	3740	3758	3776	3794
2100	3812	3830	3848	3866	3884	3902	3920	3938	3956	3974
2200	3992	4010	4028	4046	4064	4082	4100	4118	4136	4154
2300	4172	4190	4208	4226	4244	4262	4280	4298	4316	4334
2400	4352	4370	4388	4406	4424	4442	4460	4478	4496	4514
2500	4532	4550	4568	4586	4604	4622	4640	4658	4676	4694
2600	4712	4730	4748	4766	4784	4802	4820	4838	4856	4874
2700	4892	4910	4928	4946	4964	4982	5000	5018	5036	5054
2800	5072	5090	5108	5126	5144	5162	5180	5198	5216	5234
2900	5252	5270	5288	5306	5324	5342	5360	5378	5396	5414
3000	5432	5450	5468	5486	5504	5522	5540	5558	5576	5594
3100	5612	5630	5648	5666	5684	5702	5720	5738	5756	5774
3200	5792	5810	5828	5846	5864	5882	5900	5918	5936	5954
3300	5972	5990	6008	6026	6044	6062	6080	6098	6116	6134
3400	6152	6170	6188	6206	6224	6242	6260	6278	6296	6314
3500	6332	6350	6368	6386	6404	6422	6440	6458	6476	6494
3600	6512	6530	6548	6566	6584	6602	6620	6638	6656	6674
3700	6692	6710	6728	6746	6764	6782	6800	6818	6836	6854
3800	6872	6890	6908	6926	6944	6962	6980	6998	7016	7034
3900	7052	7070	7088	7106	7124	7142	7160	7178	7196	7214
C°	0	10	20	30	40	50	60	70	80	90

C°	F°
1	1.8
2	3.6
3	5.4
4	7.2
5	9.0
6	10.8
7	12.6
8	14.4
9	16.2
10	18.0

F°	C°
1	.56
2	1.11
3	1.67
4	2.22
5	2.78
6	3.33
7	3.89
8	4.44
9	5.00
10	5.56
11	6.11
12	6.67
13	7.22
14	7.78
15	8.33
16	8.89
17	9.44
18	10.00

EXAMPLES: 1347°C = 2444°F + 12°.6F = 2456°.6F; 3367°F = 1850°C + 2°.78C = 1852°.78C

convenience it has the advantage of exactness, i. e., the values of temperature found from the table are exact, not approximate.

The table covers the whole temperature range from the temperature of liquid air to that of the arc.

Advantages of Enriched Air Blast.

BY JOS. W. RICHARDS.

If we consider what effect air enriched in oxygen can have upon the working of a blast furnace, the first and immediate effect will undoubtedly be the increase in maximum available temperature before the tuyeres. What that will be can be calculated with exactness for air of any given percentage of oxygen.

The next question is, what effect this increased temperature will have upon the running of the furnace. Here calculation cannot be made with exactness, and only general observations can be made as to the effects which these high temperatures will produce.

The normal percentage of oxygen in pure air by volume is 20.8, nitrogen (argon, etc.) 79.2. For the purpose of discussing the effect of enriching the air in oxygen, upon the working of a blast furnace, we can leave out of consideration the presence of water vapor in the blast, or of the small amount of CO^2 in the air, and confine our attention to the oxygen and accompanying nitrogen.

Using cold pure air in the blast furnace, the combustion of the carbon being practically entirely to carbon monoxide, CO, the theoretical maximum combustion temperature attained is 1678° C. (Metallurgical Calculations, Part II, p. 282). If the air is preheated to 1000° C., the theoretical maximum is 2520° C., an increase of 842° C., or 84° for every 100° heat in the hot blast.

The function of hot blast is to increase the total amount of heat available per unit of carbon burnt before the tuyeres. This increase in available calories results in raising the temperature of the furnace gases in the smelting zone without changing their quantity, and thus renders available for smelting down purposes a larger quantity of heat units per unit of carbon burnt, at a ***higher*** initial combustion temperature. The net results are that the unit of carbon burnt before the tuyeres smelts down more iron and slag and smelts quicker, because of the higher initial combustion temperature. This produces less CO before the tuyeres per unit of iron smelted, resulting in a better production of CO^2 above the tuyeres, and therefore better utilization of carbon as a whole in the furnace.

The weak spot of the blast furnace is the smelting zone, and any factor which increases the amount of available heat units in that zone, and their initial combustion temperature, works great economy in the furnace.

More or less dried blast works similar results for a similar reason. The removal of moisture increases the available heat units in the smelting zone by the heat previously necessary to decompose the moisture. This results in more heat units available, and at a higher initial combustion temperature. Irregularities of temperature due to changes in the weather are also eliminated, making for more regular running, and saving the margin of excess fuel usually carried against such emergencies as a rapid increase in air humidity.

More available heat units in the smelting zone at a higher initial combustion temperature is the secret of the efficiency of hot blast and of dried blast.

It is possible to still further increase these two factors of economy. By increasing the percentage of oxygen in the air we *do not* increase the heat units available per unit of carbon burnt, but we increase, for the same available heat units, their initial combustion temperature. Operating with a blast of air preheated to 500° C., let us say, pure air gives a theoretical maximum combustion temperature of 2096° C. This is not the temperature to which the materials being smelted are raised, but is the initial temperature of the gaseous products of combustion at the moment of their formation, which products by cooling down impart their heat to the materials being smelted.

If, now, the air used is increased, say, 5 per cent in oxygen, to 25.8 per cent oxygen and 74.2 per cent nitrogen, the amount of inert nitrogen carried in is decreased 24 per cent for a given quantity of oxygen and it can be calculated that the maximum temperature of combustion will be increased to 2466°, an increase of 370°. It should be noted, however, that this increase of temperature is not accompanied by any increase in the number of available heat units per unit of coke burnt; these remain unchanged, but they are available at a much higher initial temperature.

We must next show what effect this higher initial temperature of the same number of heat units can have on the furnace running. It effects the rate of transfer of heat to the substances being smelted, i. e., the rate of smelting down. The gases produced are 16 per cent smaller in volume and at nearly 18 per cent higher temperature. They will, therefore, cool off in giving up their sensible heat to the materials being smelted very much faster; how much faster is somewhat problematical. As an estimate, we could say that the smelting operation might proceed 16 plus 18, or 34 per cent faster. This would mean an increased capacity of the furnace of one-third.

Faster running would further decrease radiation losses per unit of iron made; smaller volume of nitrogen would decrease the velocity of the gases through the charge and therefore increase the efficiency of reduction, i. e., the percentage of CO^2 in the escaping gases; the temperature of the escaping gases would also be decreased, more of their heat being thus left in the furnace. The temperature of the furnace would decrease more rapidly above the tuyeres than it now does, giving a lower average temperature to the outside furnace shell and therefore decreased radiation and conduction losses to the air. The escaping gases would be relatively richer in combustible, and therefore better fuel gas.

Summarizing these advantages, we feel confident in predicting that when a blast furnace is run on air enriched 5 per cent in oxygen, that it will run normally one-third faster than when run with ordinary air, and will save probably one-sixth the fuel requirement.

Lehigh University.

The Silver Cyanide Mill of the San Rafael y Anexas Co., Pachuca.*

By E. Girault, *General Manager.*

This mill, built in 1908, belongs to the type introduced the year before in the San Francisco Hacienda by Mr. A. Grothe, to whose foresight and personal effort we owe the most efficient

Fig. 1.—General view of the cyanide mills of the San Rafael y Anexas Company, Pachuca.

and rapid cyanide process known in Mexico, and to whom credit must be given for the valuable service thus rendered to the silver industry of Mexico.

Ores.—The ores from the San Rafael Mines, derived from the Vizcaina vein (the mother lode of the district), contain from 70 per cent to 75 per cent silica and from 10 per cent to 20 per cent of limestone. The silver, mixed with a small amount of base sulphides, is found mostly in the state of Ag_2S. The gold occurs in a nearly constant proportion of 4 grams to 5 grams per kilogram of silver in the low, and 3 to 4 in the high-grade ores. All ores above 300 grams of silver to the ton are cyanided.

Treatment.—The ore is hand-picked; crushed in Blake crushers and sampled in the mine yard; ground in cyanide solution in stamp batteries; concentrated on Wilfley tables; classified in Dorr classifiers; reground in Krupp tube mills; settled in Dorr pulp thickeners, and agitated in Pachuca pneumatic tanks.

The solutons are filtered in Moore vacuum filters and precipitated on zinc shavings.

Plans I and II show the flow through the mill.

Power and Water Supply.—The mill is driven by electric power supplied by the "Compania de Potencia de Regla." Westinghouse motors being employed.

Each battery of 20 stamps has a 75-hp motor; each Krupp mill one of 100 hp.

The total power consumption is 1.68 hp-day per ton of ore.

The water supply is drawn from the mine; the water is slightly alkaline.

Crushing.—There are 80 stamps in use; 40 Krupp, of 850 lb., set on timber foundations, and 40 Allis-Chalmers, of 1250

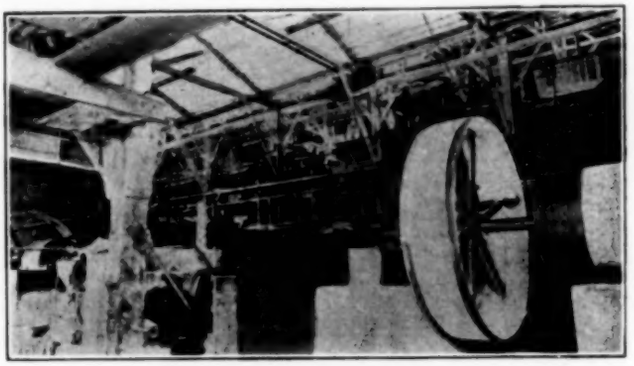


Fig. 2.—Inside view of mill.

lb., bolted to concrete foundations. The light stamps drop 7¾ in. and the heavy ones 6¾ in. 104 times per minute. The shoes and dies of forged steel last from 90 to 100 days.

Tyler's ton-cap screens, Nos. 58 and 365, equivalent to No. 10 mesh, 18- wire, 1.32 mm opening, and to No. 12 mesh, 20-wire, 1.067 mm, respectively, are used in the batteries.

The 850-lb. stamps crush from 3 tons to 3½ tons through 10-mesh per day; the 1250-lb. stamps crush from 6 tons to 6½ tons through 10-mesh, and from 5½ tons to 6 tons through 12-mesh per day.

From 7 tons to 8 tons of solution of one of ore is used in the batteries.

With No. 10 screens the capacity of the batteries is 400 tons per day, but at present crushing is limited to 350 tons to avoid overloading of the tube mills.

One pair of spring rolls, 36 in. x 16 in., and two more tube mills have been ordered; when installed No. 8 screens will be used in the batteries, and it is expected to raise the crushing to about 500 tons per day.

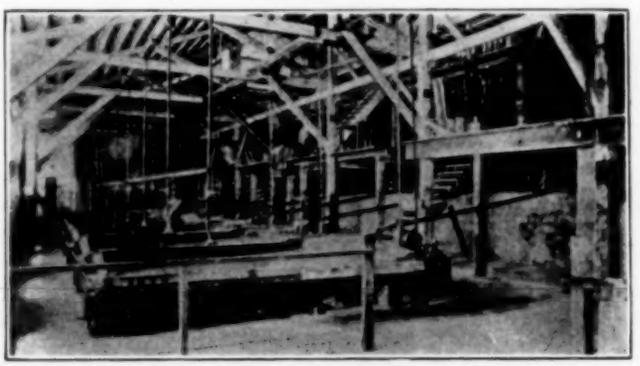


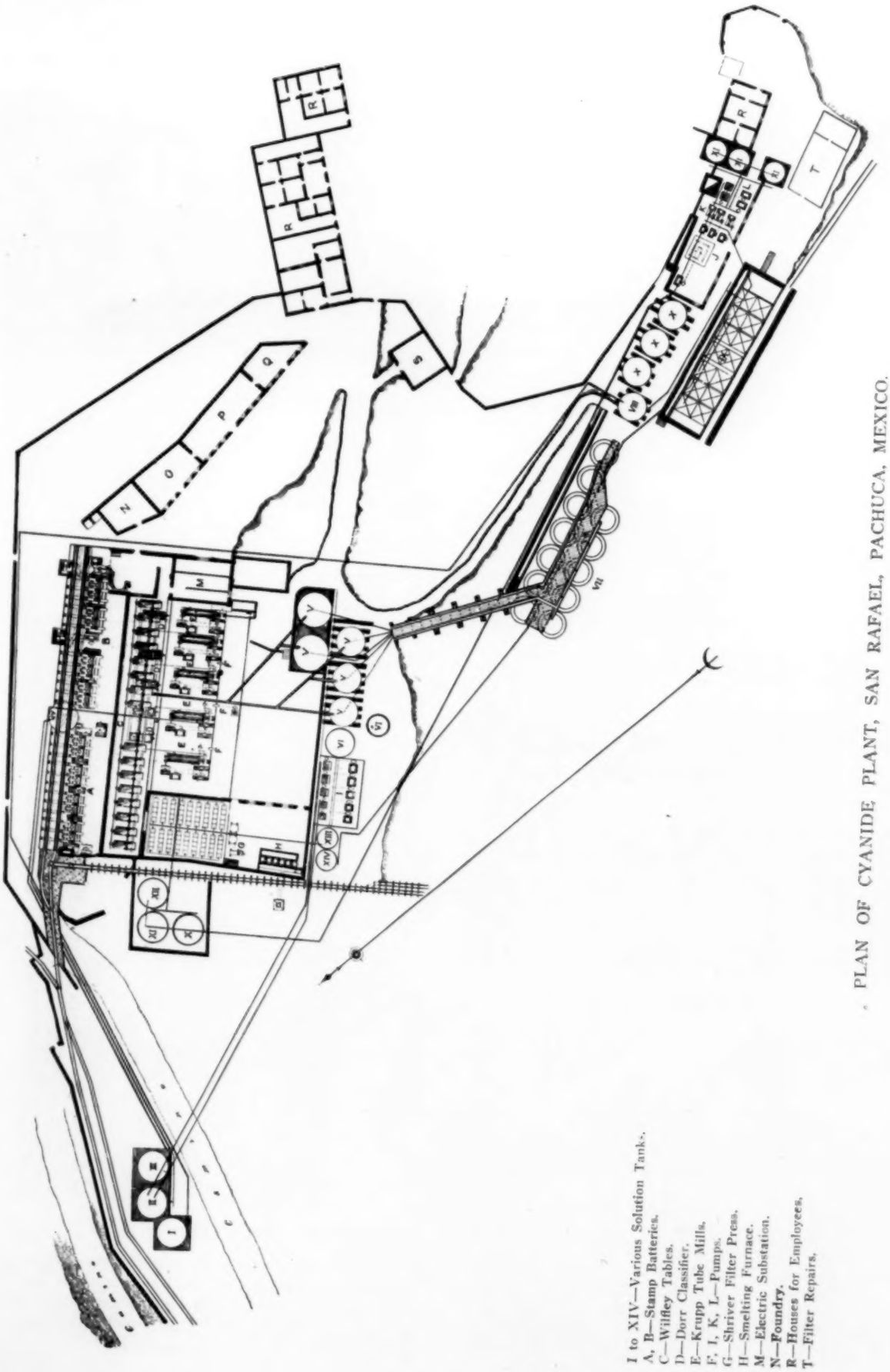
Fig. 3.—Concentration plant.

The following is a sizing test of the battery pulp, No. 58 ton-cap = No. 10-mesh screens being used.

+40	37	per	cent.
+60	9	"	"
+100	7	"	"
+150	13	"	"
+200	4	"	"
−200	30	"	"

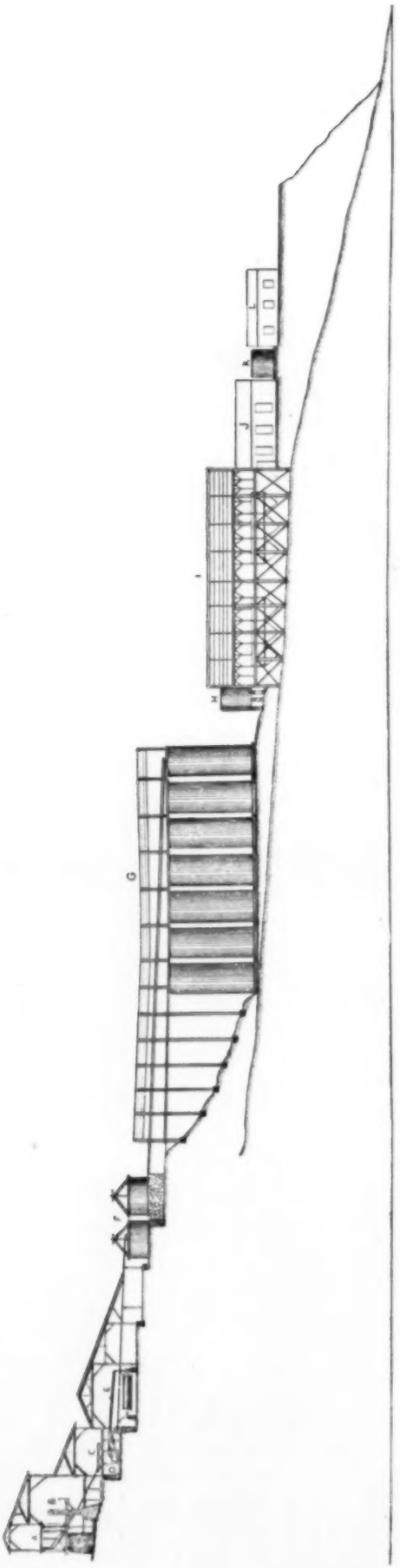
The total power consumption in grinding, including crushers, stamps and tube mills, is 1.05 hp per day per ton.

*A paper presented before the Instituto Mexicano de Minas y Metalurgia. From Informes y Memorias del Instituto vol. I, No. 3. Dec., 1909.



PLAN OF CYANIDE PLANT, SAN RAFAEL, PACHUCA, MEXICO.

I to XIV—Various Solution Tanks.
A, B—Stamp Batteries.
C—Wilfley Tables.
D—Dorr Classifier.
E—Krupp Tube Mills.
F, I, K, L—Pumps.
G—Shriver Filter Press.
H—Smelting Furnace.
M—Electric Substation.
N—Foundry.
R—Houses for Employees.
T—Filter Repairs.



CYANIDE PLANT, SAN RAFAEL, PACHUCA.

B—Stamps. C—Wilfley Tables. D—Dorr Classifiers. E. Krupp Tube Mills. F—Dorr Pulp Thickeners. G—Pachuca Tanks. I—Moore Filter. J—Compressor and Pumps. K—Rich Solution Tank. L—Houses for Employees.

Mill Solution.—This is stored in two tanks, II and III, of 200 cu. m. each; these tanks are used alternately to supply the mill and to receive the barren solution, being worked in cycles in order to avoid the enrichment of the solution.

According to the class of ore treated from 6 kg to 12 kg of

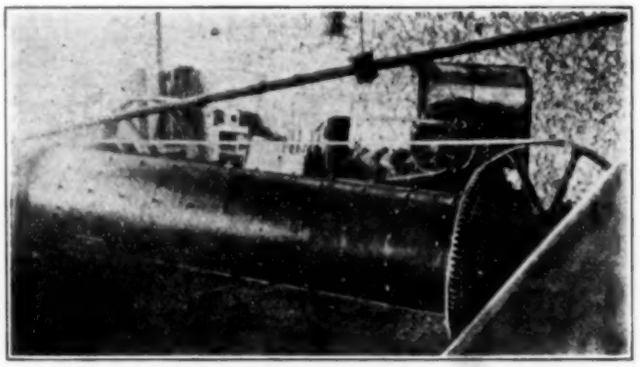


FIG. 4.—TUBE MILL.

lime are added in the bins per ton of ore. The alkalinity of the solutions is kept at 1 kg of CaO to the ton.

The mill solution averages 0.25 per cent of KCy; the cyanide loss in crushing is about 600 grams to the ton of ore. The extraction in the grinding process is high, averaging during October 38.3 per cent of the silver and 70 per cent of the gold contained in the ore.

Concentration.—Sixteen Wilfley tables, one for each five stamp battery, are used.

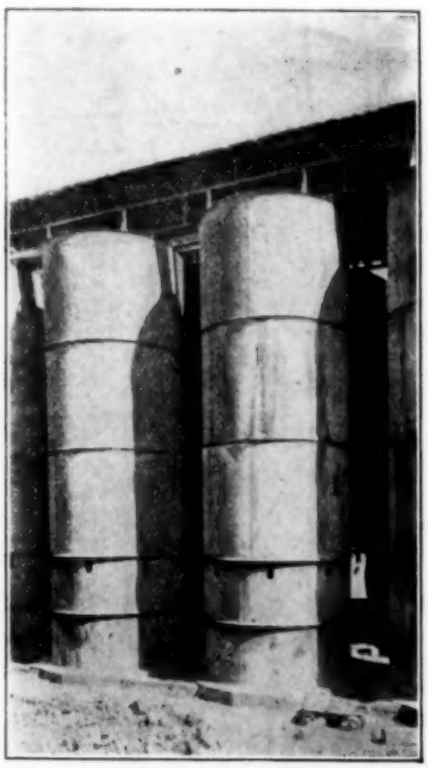


FIG. 5.—PACHUCA TANKS.

From 17 tons to 30 tons of ore per day are fed to each Wilfley without overloading them.

The Wilfley tables are also used for unwatering the pulp and as auxiliary classifiers; the slime overflow being sent to pulp thickeners.

During the month of October 22.09 per cent of the values were recovered in concentrates containing:

Silver	25.586	kg per ton.
Gold	126	gr. per ton.
Iron	34.45	per cent.
Silica	12.25	" "
Lime	3.40	" "
Sulphur	40.50	" "

The concentrates were sold to the smelters.

Classification.—Five Dorr classifiers, one for each tube mill, are used.

From 50 tons to 70 tons of pulp, all the return from the tube mill, are fed to each classifier, the pulp being in the proportion

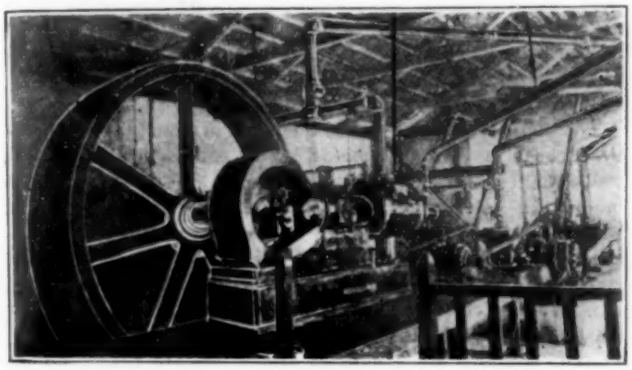


FIG. 6.—AIR COMPRESSOR.

of 1 to 2.38 of solution; the discharge contains 1 of solution to 2 of dry sand.

The Dorr classifiers have been working continuously for one year without giving any trouble.

The slime discharge classified averaged in October:

+ 100	2.5	per cent.
+ 150	15.5	" "
+ 200	7.5	" "
— 200	74.5	" "

Tube Mills.—Five Krupp No. 5 tube mills, 4 ft. x 20 ft., with Neal's baffle at both ends and El Oro liners, are in use.

Their capacity is rated at 50 tons of sand per day, the heads averaging:

+ 100	48.0	per cent.
+ 150	39.6	" "
+ 200	4.2	" "
— 200	8.2	" "

The tails, 74.5 per cent — 200, as noted above under classification.

Pulp Thickeners.—Five Dorr pulp thickeners, receiving slime diluted 1 to 10 and discharging 1 of dry slime to 1.2 of solution, are employed to unwater the pulp previous to agitation in the Pachuca tanks.

Three of the thickeners, 20 ft. x 10 ft., are supplied with 70 tons of dry pulp each; the other two, 24 ft. x 10 ft., will take 100 tons per day, and all overflow clear solution.

Pachuca Tanks.—Ten 15-ft. x 45-ft. Pachuca tanks are used for the agitation of the pulp at present; two more have been ordered and are soon expected.

The average charge is 100 tons of dry slime and 120 tons of solution.

One part of slime to one of solution (120 tons of slime to 120 of solution) has been tried, as well as 1 to 2, and 1 to 3 solution, but the best proportion was found to be 1 of ore to 1.2 of solution.

Compressor.—One Rand-Ingersoll air compressor, 18¼ in. diameter by 16 in. stroke, delivering at 100 revolutions 700 cu. ft. of air per minute to elevation, is employed for supplying air to the Pachuca tanks, to the Moore filter tanks, etc.

The amount of air required for an energetic agitation in the Pachuca tanks is estimated in San Rafael at 100 cu. ft. per minute at 25 lb. pressure.

The pulp is agitated during 36 hours, as it has been found that during this period the silver extraction increases about 20 gr.

Filtration.—Two units of the type A No. 3 of the Moore filter are employed; a third unit has been ordered.

The leaves are 10 ft. x 6 ft., and their capacity is 2.5 tons of dry slimes per day; 160 leaves in four baskets of 40 each are used, and 80 more are kept in reserve for repairs.

Two traveling cranes, worm-geared with 30 hp for traveling, are used for transferring the baskets.

According to the condition of the leaves a 1-in. cake is formed in from 20 minutes to 30 minutes.

One hour barren solution wash, and 15 minutes water wash are given to the cakes.

On each basket one 16-in. x 20-in. spiral pipe serves as vacuum chamber and holds the cake during the five minutes of the transfer.

In order to clarify the solutions, sand filters are used before the zinc boxes.

During October the water discharge assayed 4.5 gr. of silver to the ton; the cake, 55 grams unwashed and 50 grams washed.

During November, treating higher-grade ores and employing three baskets only, one of them in bad state, the cake discharged assayed 71 grams of silver unwashed and 63 grams washed.

Precipitation.—Zinc shavings, 0.006 in. thick, are used in precipitation.

Two tons of solution to the ton of ore are precipitated.

The heads in the boxes assay from 200 grams to 300 grams of silver; the tails, 2 grams.

The clean-up is made weekly.

The short zinc, which remains on a 20-mesh screen, is returned to the boxes; the shorts on 40-mesh are melted.

The precipitates are pressed and dried to 20 per cent moisture on a 24-in. x 24-in. Shriver press.

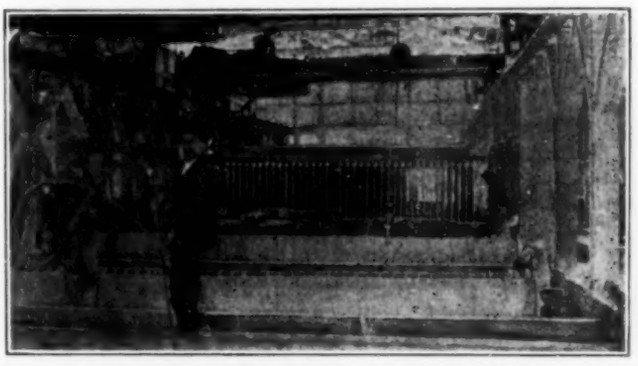


FIG. 7.—MOORE FILTER PRESS.

Melting.—Coke furnaces and Dixon's No. 300 graphite crucibles are employed.

The precipitate is melted with the following flux:

15 per cent broken glass.
6 per cent borax.
4 per cent sodium carbonate.

The short zinc, which remains on the 40-mesh screen, is fused with:

20 per cent broken glass.
8 per cent borax.
6 per cent sodium carbonate.

The bars, without remelting, assay from 920 gr. to 930 gr. silver and 5 gr. of gold to the kilogram of silver.

The slags are crushed quarterly in a battery and concentrated on a Wilfley table. The concentrates are melted and the tails treated in the cyanide plant or sold.

Resume.

The resumé of the November, 1909, results is given below:

Tons crushed, 8393.

Assays per ton of ore:

Ore Contents:

Silver	0.901 kg	(28.967 oz. troy).
Gold	4.430 gr	(0.151 oz. troy).

Concentrates:

Silver	25.348 kg	(814.938 oz. troy).
Gold	141.600 gr	(4.552 oz. troy).

Heads of Pachuca tanks:

Silver	0.397 kg	(12.763 oz. troy).

Filter discharge:

Unwashed silver	0.071 kg	(2.283 oz. troy).
Washed silver	0.063 kg	(2.025 oz. troy).

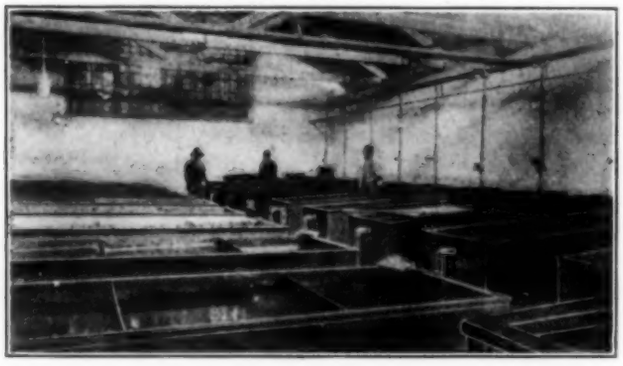


FIG. 8.—PRECIPITATION BY ZINC SHAVINGS.

Extraction:

In concentration, silver	24.19 per cent.

Cyaniding:

Crushing	31.74 per cent.
Agitation	36.18 " "
Total extraction, by assays, silver	92.11 " "
Total extraction, by calculation, silver	91.43 " "
Total extraction, by calculation, gold	97.08 " "

Consumption per ton of ore:

Sodium cyanide, 128 per cent	1.078 kg.
Lead acetate	0.317 "
Lime	6.706 "
Flint pebbles	1.227 "
Zinc	0.843 "
Coke	1.646 "
Borax	0.084 "
Soda carbonate	0.044 "

The cost per ton was:

General expenses	$0.78
Grinding and concentrating	1.18
Cyaniding	1.32
Pumps and compressor	0.15
Filtration, including royalty	0.33
Precipitation and melting	0.44
Total Mexican money	$4.20

Properties and Behavior of Furnace Electrodes.

By Carl Hering.

In an article in the October issue of this journal (Vol. VIII, p. 442, 1909) the writer described an analysis of the laws of the proper proportions of electrodes and the losses of energy in them, based on the fundamental principle that there should be no chilling of the furnace by the electrodes or unnecessary heating within the walls. Owing to the great mathematical complications involved by including in the algebraic deductions some of the refinements which belong more properly to what is termed the second approximation in a complicated case, the writer preferred the method more generally used in such cases and recommended by our ablest scientists, to take up the simpler case first by itself, and consider the refinements later in the form of corrections. He then showed how most of these corrections could readily be taken care of by determining the physical constants in such a way as to include those factors, thus making the simple solution practically exact.

In any case, no matter how complicated, and as far as it concerns the electrode as a whole, that is, the end results only, an electrode may always be considered to be replaced by another whose conductivities are uniform throughout and equal to the mean, virtual or average conductivities of the original one; this equivalent electrode then follows the simple laws developed by the writer. The end results, that is, the flows of heat at the two ends, will be the same in the equivalent electrode as they are in the original, but the behavior of the parts intermediate between the ends will not.

The whole subject is discussed more in detail, accompanied by experimental determinations, tables and curves, in a paper on "The Proportioning of Electrodes for Furnaces" to be read before the American Institute of Electrical Engineers and to be published in the *Proceedings* of that society for March.

Although the problem of calculating electrodes so as to include these corrections is thereby solved in a very simple way, it is nevertheless quite instructive and of interest to examine what the nature of the changes in the behavior of the intermediate parts of the electrodes are, which are caused by the different physical properties of the materials, including the temperature variations in the conductivities. The purpose of the present article is to do this.

When a mathematical analysis becomes so complicated that it confuses and obscures rather than clarifies the situation, one may often obtain very useful results by means of analogies. In the present article the effect of those changes will be examined in this way.

The comparisons will be made between a flow of electricity (an electric current), a flow of water, and a flow of heat.

Analogies.—In Fig. 1 let E be a very large electrically charged sphere whose potential above the earth is E. Let the conditions be that a wire R of a uniform resistance must be attached to it and to the earth; a current C would then flow whose value is $C = E/R$, supposing the charge to be practically infinite, and R to be the resistance through which the current passes. This current is a flow of coulombs per second. Let it be required to stop this flow without opening the circuit. This can evidently be done by passing a current equal to C from some other source into the wire at the extreme end a near the sphere. Or it may be done by a current equal to $2C$ applied at the middle point b; or by a current $10C$ applied at a point c, which is 9/10 of the whole distance from the sphere.

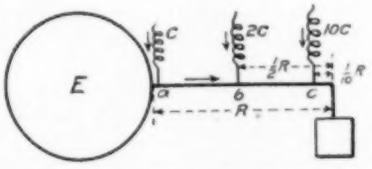


FIG. 1.— ELECTRICAL ANALOGY.

It will be seen that the current which is required increases in the same proportion as the point of application is moved nearer the zero end. In all cases E is always the same, and C increases as fast as R diminishes, so that their product is always equal to E. But the power required is $C\,E$, hence it will increase in proportion to C—that is, it will require the least power when the current is applied at a, and most when applied at c.

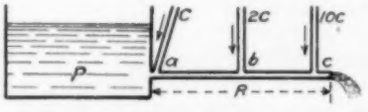


FIG. 2.—ANALOGY WITH FLOW OF WATER.

It will be noticed that when the current is applied at the

middle point *b*, it amounts to the same thing as a current entering the wire all over its whole length, at a uniform rate per inch. Or in other words, the points *a*, *b* and *c* may be considered to be the centers of gravity of currents entering all over the wire, evenly for the point *b*, and unevenly for the points *a* and *c*. If for any other distribution of the entering current the center of gravity of the distribution is known, the above laws may be applied.

In Fig. 2 let *P* be a tank of water with a pipe *R* attached to it having a resistance to the flow; and assume for the sake of the analogy, that this resistance also follows a law like Ohm's law. Then exactly the same argument applies to stopping the outflow of water from this tank dynamically by streams of water entering the pipe at various points *a*, *b* and *c*, or all over, either regularly or irregularly, the center of gravity of such distributed influx being known.

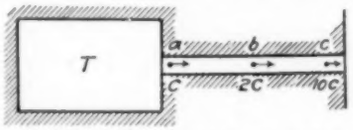


FIG. 3.—FLOW OF HEAT IN ELECTRODE.

In this case it is the hydraulic pressure *P* of the tank which is always the same, and the various currents *C*, now the current or flow in gallons per second, must always be such that $C = P/R$. The current and the power to produce it will again increase in proportion as the center of gravity of its application moves away from the tank.

In Fig. 3 let *T* be a furnace having a constant temperature *T*, and let *R* be an electrode offering a resistance to the flow of heat, and having its other end kept cold. The analogy applies again. The flow of heat *C* from the furnace is again such that $C = T/R$, the temperature *T* being now that quantity which is always the same. This flow can again be stopped by the application of another flow in the same direction from an independent source. If the resistance again follows Ohm's law, as it does, the same conclusions apply as those found above, namely, that the flow of this applied heat will be least when applied near the furnace end, and will increase as the center of gravity of its application is farther from the furnace. The flow or current is now measured in calories per second, which is a quantity of the same nature as watts. In this case the heat current itself is power, hence the flow or current and the power to produce it are numerically the same.

The number of watts required to stop the flow from the furnace will therefore increase in the proportion as the center of gravity of the inflow from the other source is farther removed from the furnace. It will be greater or less than 2*C*, depending upon whether the center of gravity of its point of application is to the right or left of the middle point *b*, respectively.

Now, this inflow of watts may be produced by an electric current in the electrode *R* itself, as it actually is done in practice. The rate of production of these watts along the electrode will then depend upon the local resistance—that is, the electrical resistivity at the various places. If it is evenly distributed—that is, if the resistivity is constant for all temperatures, it will be equivalent to all the watts being generated at the middle point *b*. In that case, from the analogy, the power required will be twice that represented by the watts of heat flow from the furnace if there were no additional current. This is the case assumed by the writer in the analysis referred to above.

Varying Electrical Resistivity.—Now let it be assumed first that the thermal conductivity is constant throughout, and that the electrical resistivity falls with the temperature, as it does with carbon. Then it is evident that more watts will be generated in the colder half than in the hotter one. Hence, the center of gravity for the whole length will be moved toward the colder side of the middle; hence, the conditions will approach to those in Fig. 3, in which the watts are applied at *c* near the cold end. From the analogy it follows that the watts now required to stop the furnace flow will be *greater* than they were for an electrode having the same total resistance but evenly distributed. And they will become greater the faster the resistivity falls with the temperature. As these watts are the electrode loss, it follows that *a falling resistivity increases the loss*, because it moves the center of gravity of the generation of the watts toward the cold end.

Hence, a falling resistivity is an undesirable feature for an electrode. In unscientific terms, it may be said that it crowds the heat toward the cold end where it is not wanted. In Fig. 4, if *b* is the normal heat gradient for a constant resistivity, then a falling resistivity will tend to give it a shape more like the curve *c*, which is undesirable.

Let it now be assumed that the resistivity rises with the temperature, as it does with iron. In an iron electrode more watts will be generated in the hotter than in the colder half. This moves the center of gravity of the total watts toward the hot end; hence, the conditions will approaoch those in Fig. 3, in which the watts are applied at *a* near the hot end. It has been shown that the watts required to stop the flow of furnace heat will then be *less* than when applied at the middle. Hence, in iron electrodes less watts will be required to stop the flow of furnace heat than if the resistivity were constant. And the number of watts will become less and less as the resistivity rises more rapidly with the temperature.

Hence, as these watts are the electrode loss, it follows that *a rising resistivity diminishes the loss*, and is therefore a desirable feature in an electrode. It may be said that it crowds the heat toward the hot end, which is the right place for it to be. Referring to Fig. 4, it tends to change the normal heat gradient from *b* toward *a*, which is very desirable; the more rapidly this curve falls at the hot end and the less rapidly at the cold, the better.

Varying Thermal Conductivity.—Now let it be assumed that the electrical resistivity is constant and that the thermal conductivity varies with the temperature. The watts will then be generated evenly throughout the whole length.

When the thermal conductivity falls with the temperature it means that the heat gradient will fall more rapidly in the hot half and less rapidly in the colder half than it would for a constant conductivity. Referring to Fig. 4, it will tend to change the heat gradient from *b* to *a*. This, as was pointed out above, is in the right direction. Hence, *a falling thermal conductivity is a desirable feature.*

When, on the other hand, the thermal conductivity rises, it means that the heat gradient will fall less rapidly in the hotter half and more rapidly in the colder one than for constant conductivities. Referring to Fig. 4, this will tend to change the normal gradient *b* to the undesirable one *c*. Hence, *a rising thermal conductivity is an undesirable feature.*

Examples.—Recent determinations of these physical constants by the writer show that up to about 1000° C., and probably above that also, carbon has a falling electrical resistivity, and a rising thermal conductivity (not a falling one, as has been incorrectly claimed.) Hence, in this material both features are in the undesirable direction, as they both tend to crowd the higher temperatures toward the colder end, where they are not wanted; and as was shown above, this increases the minimum loss. As both these tendencies are in the same direction, each in turn helps to increase the other, making the final heat gradient worse than it was for either alone. The heat gradient for a carbon electrode will therefore be somewhat like the curve *c* in Fig. 4.

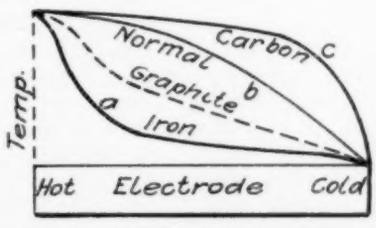


FIG. 4.—TEMPERATURE GRADIENTS.

On the other hand, these same determinations have shown that for iron the electrical resistivity rises rapidly and the

thermal conductivity falls. Hence, both are in the favorable direction, as they both tend to crowd the higher temperatures back toward the furnace where they belong; and this tends to reduce the minimum loss. Again, as both features act in the same direction, each in turn will increase the other, making the final heat gradient better than it would be for either alone. The heat gradient for an iron electrode will therefore be somewhat like the curve *a* in Fig. 4.

For graphite these tests showed that the electrical resistivity falls, though much less rapidly than for carbon, at least for moderate temperatures; it is, in fact, not very different from a straight line. Graphite, therefore, shares this undesirable feature with carbon, though it possesses it to a less degree. But, on the other hand, the tests showed that the thermal conductivity falls, and quite rapidly, much more rapidly than for iron. Hence, it shares this good quality with iron. As these two features are now opposed to each other in their action on the heat distribution in an electrode, they tend to neutralize each other; but as the rate for the falling thermal conductivity is considerably greater than that for the rising electrical resistivity it predominates, the result being that it moves the heat gradient below the normal one *b*, Fig. 4—that is, toward the one for iron, *a*, which is the favorable direction. Hence, graphite, like iron and unlike carbon, tends to crowd the heat toward the hot end where it belongs.

This feature was also confirmed by a comparison of the resistivities of graphite *at* various temperatures with those obtained by the writer, which are the mean values for various ranges of temperatures. The rate of change of the latter was found to be less than that obtained by the arithmetic means of the former, as it should be.

Thermal Insulation.—Incidentally, the different shapes of the heat gradients in Fig. 4 indicate the error that would be committed by assuming any fixed coefficient for the leakage of heat from the electrode to the walls, as has been suggested. This leakage, however little or much it may be, depends, of course, on the differences between the temperatures of the electrode and of the wall at neighboring points. Now, the heat gradient in the wall will presumably be approximately a straight line joining the two ends of the heat gradient curves in Fig. 4. Hence, for carbon the leakage would be from the electrode to the wall, while for iron and probably graphite, too, it would be from the wall to the electrode; hence, not only different in values and in place, but even with a reversed sign! This shows the great mistake that might be made by measuring such a coefficient for carbon, for instance, and then applying it to an iron or graphite electrode; it would make matters worse than to let it alone.

Electrode Means.—The empirical values above referred to are the proper mean values to be used in the formulas developed by the writer and given in the earlier paper above referred to. They are the values of an equivalent electrode whose two conductivities are constant throughout the whole length of electrode and are equal to this value for each particular range of temperature, but have a different constant value for a different range. Such an electrode *as a whole* will act just like the original one, differing only in the distribution of the heat between the ends—that is, in the heat gradient, as was discussed in this article. As these values are a mean peculiar to electrode conditions, being neither exactly an arithmetic or geometric mean, the writer proposes to designate them by the term "electrode mean."

It may be of interest to add here that when these electrode mean values are used all the laws of electrode losses deduced by the writer in his former article seem to apply correctly even when the variations of the conductivities with temperature are very great. The explanation seems to be that these experimentally determined mean values embody all the correction factors due to these variations.

The results of these experimental determinations are in part surprising, as they show that some of our former figures have been considerably in error, in one case even in the direction (sign) of the variation. This is in part due to the fact that they are the electrode means and therefore include the effects of the variations pointed out in this article.

Carbon turns out to have a much higher mean thermal conductivity than was formerly supposed, bringing it up to about half that of graphite instead of 1/8 and 1/10, as has been claimed. This high mean value is undoubtedly due in part to the properties described in this article. For graphite it is also higher, being above that for iron. These data are published elsewhere in detail, but briefly it may be said here as a confirmation of what has been deduced in this article, that for a range of temperature of about 1400° C. to 100° C. the minimum losses are about in the following ratios: Copper, 1; iron, 1.5; graphite, 5.0, and carbon, 7.5. While as to the size, the proportions are about: Copper, 1; iron, 6.6; graphite, 14.5, and carbon, 45.

The writer's researches have, therefore, shown that in almost, if not even in all these features, the material which has been most used for electrodes, namely, carbon, is the worst, while by far the best, if it could be taken advantage of, would be copper.

Another result of the writer's investigations showed that, although the two conductivities of electrode materials are interesting, instructive and useful quantities in an investigation of this kind, and enable the behavior of the electrodes to be studied, neither of them alone are direct measures of the desirable qualities of a material for electrodes, as was clearly described in his earlier articles and papers. This led to finding what physical properties are the true relative and absolute measures of the desirable qualities of materials when used for electrodes, and this, in turn, shows that when these latter constants are determined, the two conductivities are no longer concerned and, therefore, need not even be known at all for calculating the proportions of electrodes or the losses in them. In fact, these conductivities have in the past even misled us to quite wrong deductions and conclusions, some of which have become so deep-rooted that it will be difficult to correct them. By using these new and more rational physical properties, and deductions from them, the extreme simplicity of the calculations brings them almost into the same class as those based on Ohm's, Faraday's and Joule's laws. These two new quantities are the electrode voltage and the spectific section, as also their derivatives for specified temperature ranges, as explained more in detail in the paper above-referred to.

PHILADELPHIA, Feb. 14, 1910.

Definition of Industrial Terms.

At the recent annual meeting in Boston of the Division of Industrial Chemists and Chemical Engineers of the American Chemical Society, a committee was appointed by the chairman, under authority of the by-laws of the section, "On the Definition of Industrial Terms." In constituting this committee, it is the desire of the division that it co-operate as far as possible with trade organizations in the several lines of industry in formulating definitions of their products which shall be as accurate and as fair as possible to the interests involved. The organization of such a committee has been suggested by various interests who desire a more authoritative definition of some industrial terms such as "petroleum ether," "gasoline," "benzol," "bronze," "benzine," "steel," "Portland cement," etc.

The general committee is desirous of receiving suggestions from all who are interested in the subject as to terms which are considered the most important to be defined at the present time, owing to ambiguities which may now exist, and as to the best methods of accomplishing the work. All communications should be addressed to Mr. Clifford Richardson, 30 Church Street, New York City, who is chairman of the committee, the other two members being Messrs. J. B. F. Herreshoff and George T. Adamson.

The Magnetic and Electrical Properties of Iron-Silicon Alloys.

BY CHARLES F. BURGESS AND JAMES ASTON.

The belief was held for a long time that, as far as magnetic properties were concerned, purification was the method to be looked to for improvement of iron; that the highest permeabilities were to be reached the nearer our material approached an analysis of Fe 100 per cent.

That this is not true is now, of course, common knowledge. The work of Barrett and Brown, in 1901,[1] on alloy steels, made by Hadfield, gave for irons with additions of 2¼ per cent of aluminium or 2½ per cent of silicon permeabilities excelling those of pure iron; investigations of the author have shown this same effect by additions of about 2 per cent of tin or about 4 per cent of arsenic.

It is not probable that the influence of these elements, all non-magnetic, is directly, or in a strict chemical sense, the cause of the marked improvement of magnetic quality. It is more likely that the effect is due indirectly through some change in the physical structure of the iron itself. This supposition is seemingly confirmed by the influence of the heat treatment of high-purity iron. Annealing at lower temperatures

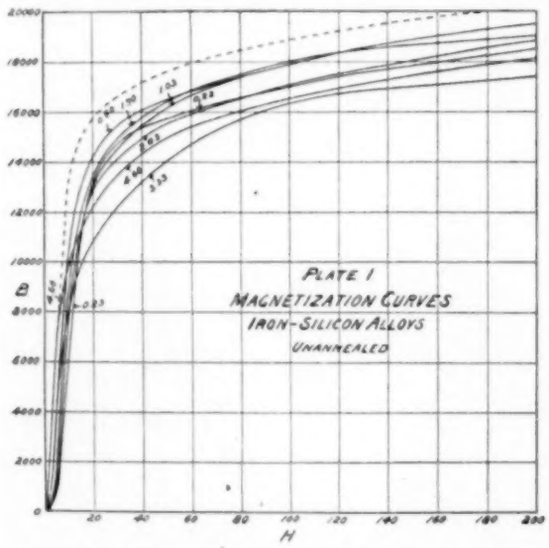


FIG. 1.—MAGNETIZATION CURVES, ALLOYS. UNANNEALED.

(about 700° C.) results in improvement of quality throughout the entire magnetization curve, due to the removal of all cooling and forging strains; while annealing at the higher temperature of 100° C. results in a deterioration of quality in the upper ranges, and a higher permeability at low magnetizing forces. And, of course, we have the concomitent increase in the grain size of the iron.

From the investigations of Hadfield, Barrett and Brown has resulted the present-day materials so largely used in transformer work, in which the percentage of silicon varies from about 3 per cent to 6 per cent. In these silicon steels the heat treatment is of importance comparable with that of the silicon content, and the practice seems to be annealing at high temperatures. The result is a material of very high permeability for the lower magnetizing forces; the saturation limit is reached at comparatively low densities, however, and beyond this point the quality is not exceptional. This characteristic makes the steel particularly suited to alternating-current working, where low working densities are the rule. The low hysteresis losses, together with the added benefits of high electrical resistance and slight deterioration due to ageing, are the special features of the silicon steels.

[1] "The Conductivity and Magnetic Properties of Alloys of Iron," W. F. Barrett and W. Brown, Jour. Inst. Elec. Engrs., Vol. 31, p. 675.

Our investigations[2] covered tests of 15 iron-silicon alloys, of which the following seven bars were analyzed and form the basis for discussion.

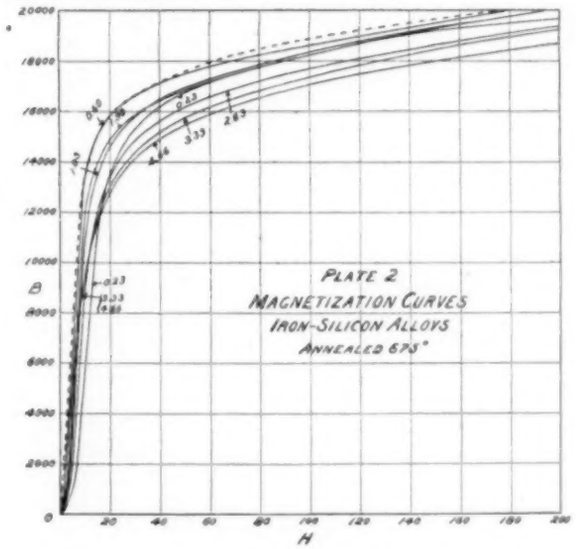


FIG. 2.—MAGNETIZATION CURVES, IRON-SILICON ALLOYS. ANNEALED 675°.

Bar.	PER CENT SILICON. Added.	Analysis.
96F	0.25	0.233
96A	0.50	0.603
96B	1.0	1.033
96C	2.0	1.897
109A	3.0	2.826
113V	7.0	3.334
96H	5.0	4.655

The agreement between added and actual silicon content is close, except for bar 113V.

As mentioned in articles which have appeared previously in this journal, electrolytic iron of high purity (99.9+) formed

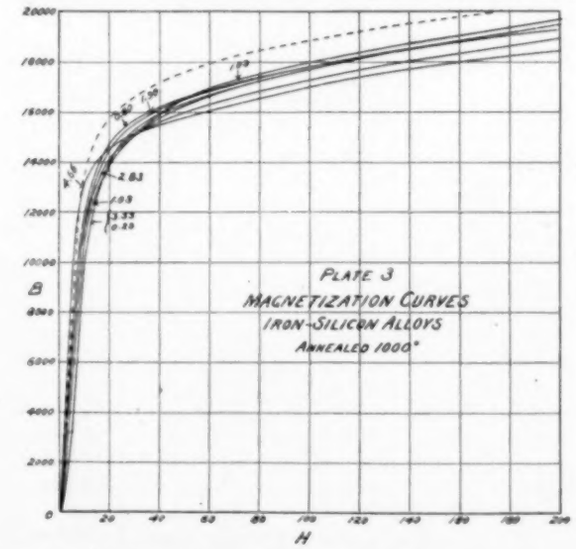


FIG. 3.—MAGNETIZATION CURVES, IRON-SILICON ALLOYS. ANNEALED 1000°.

the basis of the alloys. All effects noted, therefore, may be ascribed, as far as due to chemical composition, to the added element alone. These alloying materials were melted into ingots, which were forged and turned into bars for testing.

[2] A research on "Electrolytic Iron and Alloys" at the University of Wisconsin, under grant of the Carnegie Institution of Washington.

The results of the tests are noted in Tables I and II and in Plates 1, 2, 3, and 4. Four heat treatments were adopted—as forged, annealed at 675° C., annealed at 1000° C., and quenched at 900° C. Comparison is made with a standard bar of electrolytic iron of high magnetic quality; this is indicated in the plates by a dotted curve.

The values of retentivity given in Table II reflect the conditions indicated by the magnetization curves, and vary with the maxima reached by the curves. In general, the coercive forces become less with annealing, and reach a minimum after heating to 1000°. Quenching has had a slight tendency toward increase. The very low value of 2.7 is reached by bar 96H (Si

TABLE I.—DATA OF MAGNETIC TESTS.

Bar.	Per cent Silicon.	H = 10				H = 20				H = 50				H = 100			
		Unann.	Ann. 675°.	Ann. 1000°.	Quench 900°.	Unann.	Ann. 675°.	Ann. 1000°.	Quench 900°.	Unann.	Ann. 675°.	Ann. 1000°.	Quench 900°.	Unann.	Ann. 675°.	Ann. 1000°.	Quench 900°.
117A	0	13100	10000	13350	11800	15750	15950	15450	14600	17600	17700	17050	16950	18850	18850	18200	18150
96F	0.23	6500	6000	9750	7850	13100	13250	13700	11550	15750	16700	16250	15850	17000	18350	17700	17700
96A	0.60	10700	13100	11750	12150	14150	15800	14700	14950	16450	17500	16550	16900	17850	18600	17800	18100
96B	1.03	8100	10700	10700	11800	13100	14450	13650	14650	16150	16850	16550	16650	17850	18200	17950	17950
96C	1.90	9200	11600	11200	9150	13450	14850	14450	12250	16350	16800	16500	15850	17950	18200	17750	17600
109A	2.83	8200	8900	11200	10000	12800	13250	14050	13050	15500	16150	16000	15950	17050	17700	17300	17550
113V	3.33	8000	9100	9750	10700	10800	12950	13850	14000	14050	15750	16350	16150	16350	17350	17750	17600
96H	4.66	9750	9300	12050	9100	12200	12700	14550	13200	14950	15400	15750	16250	16500	17100	17000	17600
M E	Com.			12300				14400				16100				17700	
S E	Com.			10100				13100				16300				18000	
252	Com.			10700				13500				16400				17900	
182	Com.			11550				13850				15800				17550	

In the unannealed condition all the curves fall considerably below the standard, particularly in the upper ranges; the best results are obtained with bars of lower silicon content, and the lowest with those of highest silicon, viz., 113V, with 3.33 per cent Si, and 96H, with 4.66 per cent. However, it will be noted that for the very low values of H these two bars, and particularly 96H, cross the other curves and have the highest permeability of the series.

Annealing at 675° has raised the maxima of all curves, but the comparative order is about as in the previous condition. Bar 96A, with a low silicon percentage of 0.603, lies very close to the standard throughout the entire length.

Second annealing at the higher temperature of 1000° has resulted in a falling off of the permeability for these bars of lowest silicon content. But for three bars of highest percentage of silicon, viz., 109A (2.83 per cent, 113V (3.33 per cent) and 96H (4.66 per cent), there has been a considerable improvement of quality at the lower magnetizing forces, with but little change for the upper ranges. Here the curves fall below those of lower silicon, and all are well below the standard. The effect is most striking for bar 96H, with the highest silicon of the series

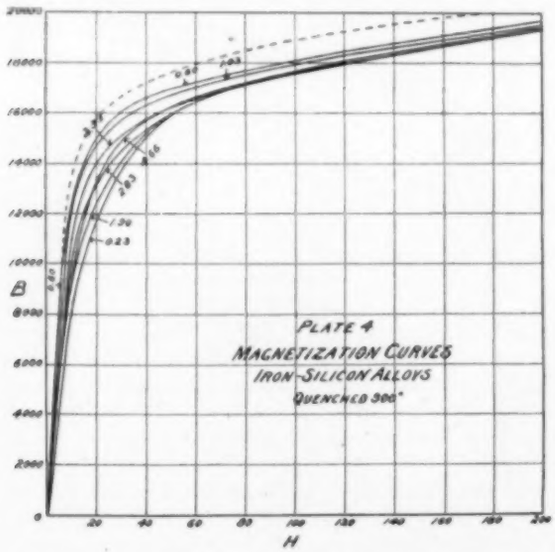


FIG. 4.—MAGNETIZATION CURVES, IRON-SILICON ALLOYS. QUENCHED 900°.

(4.66 per cent); its permeability is very high below H = 10. At this point the curve has a very sharp bend, and thereafter falls below the others. Quenching at 900° has resulted in a deterioration of quality, particularly in the lower ranges, with but little change at higher magnetizing forces.

4.66 per cent) after annealing at 1000°, confirming the previous deductions of high permeability for this alloy at low magnetizing forces.

Summarizing, the results of these tests do not show a general improvement of permeability due to the presence of silicon

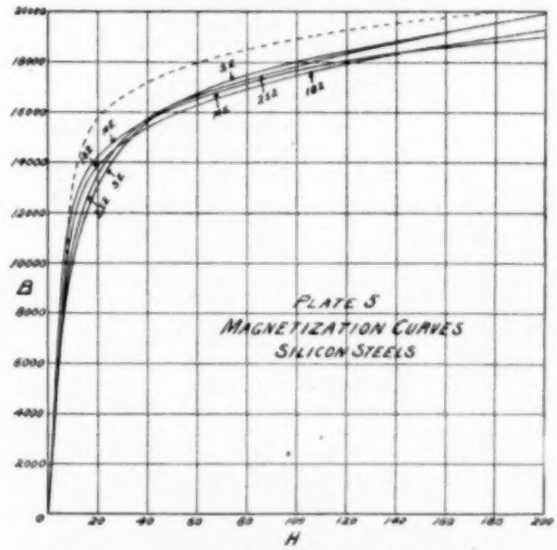


FIG. 5.—MAGNETIZATION CURVES, SILICON STEELS.

in electrolytic iron, but the experience of practice is confirmed in that a high-silicon alloy after annealing at high temperature is of high permeability for very low magnetizing forces and

TABLE II.—COERCIVE FORCE AND RETENTIVITY.

Bar.	Per cent Si.	H (Max.) = 200 Coercive force.				H (Max.) = 200 Retentivity.			
		Unann.	Ann. 675°.	Ann. 1000°.	Quench 900°.	Unann.	Ann. 675°.	Ann. 1000°.	Quench 900°.
117A	0	5.5	6.2	3.1	3.5	12300	13800	10000	8000
96F	0.23	8.6	9.4	5.2	4.3	11700	13800	9200	8000
96A	0.60	5.2	4.5	3.5	3.5	11500	13200	9000	10100
96B	1.03	7.5	6.8	4.1	4.0	12400	14200	9400	10000
96C	1.90	7.7	6.5	4.0	4.3	11800	14100	9300	9100
109A	2.83	8.5	8.2	4.7	5.1	12900	14300	10000	9900
113V	3.33	5.5	5.5	4.5	4.3	8700	11300	8500	9100
96H	4.66	4.5	4.9	2.7	3.3	12080	12800	8000	5600
M E	Com.			2.3				9700	
S E	Com.			2.5				6100	
252	Com.			3.0				8700	
182	Com.			3.5				10600	

densities such as are used in transformer design. The improvement is not so great in our tests as it is in commercial materials; it may be that the effect of the silicon is more pronounced in the presence of certain impurities or after special heat treatment.

Comfhercial Steels.

For the purpose of comparison there is appended in Tables I and II, and plotted in Plate 5, results of tests on commercial silicon steels, the samples being obtained from steel and electrical manufacturers. The tests were made upon the same apparatus as those discussed above, and the results are thus strictly comparable. The dotted curve of Plate 5 is that of the electrolytic iron standard.

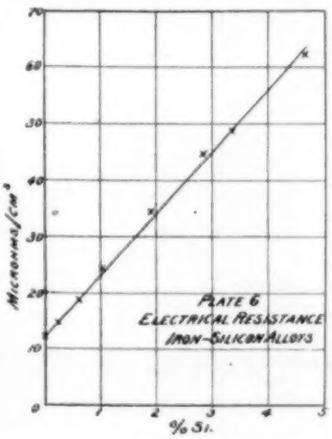


FIG. 6.—ELECTRICAL RESISTANCE IRON-SILICON ALLOYS.

The general character of the silicon steel is well shown and needs no special comment. Curves SE and 252 are of the same brand of material from a large sheet-steel manufacturer, but from samples obtained from different electrical concerns at different periods of time. The uniformity of the material is very striking; this is brought out with great clearness below, where the hysteresis tests data are tabulated.

All inductions have been carried to a maximum of B = 12,000.

Bar.	Per cent Si.	Loop area.	Relative area.	H (Max.)
117A	0	8.65	1.	8.2
96F	0.23	12.58	1.45	30.0
96A	0.60	7.05	0.81	12.5
96B	1.03	8.72	1.01	13.3
96C	1.90	9.53	1.10	1.80
109A	2.83	10.96	1.27	18.0
113V	3.33	8.77	1.02	13.4
96H	4.65	4.39	0.51	7.5
M E	Coml.	5.20	0.60	8.7
SE	Coml.	5.77	0.67	14.7
252	Coml.	6.10	0.71	14.1

These results are hardly a fair criterion of the quality of the electrolytic samples, since all were tested after quenching at 900°.

Electrical Resistance.

A feature of steels for transformer working, second only to the magnetic quality, is a high electrical resistance, to reduce the eddy-current loss. In this respect the silicon steels are an additional advantage.

Measurements of the series discussed in this paper are given in the following table:

Bar.	percent Si.	Microhms per cm³.	Relative resistance.
117A	0	12.1	1.0
96F	0.233	14.7	1.22
96A	0.603	18.7	1.55
96B	1.033	24.3	2.01
96C	1.897	34.4	2.84
109A	2.826	44.6	3.68
113V	3.334	48.6	4.02
96H	4.655	62.2	5.13
182	Coml. silicon	59.5	4.92

The above data are plotted in Plate 6, where the effect of increasing addition of silicon to the iron is indicated as an maximum of 4.65 per cent.

At this content (and this is the alloy with the minimum hysteresis loss) the resistance has risen to upward five times that of the electrolytic iron standard.

CHEMICAL ENGINEERING LABORATORIES,
UNIVERSITY OF WISCONSIN.
MADISON, WIS.

Manufacture and Transport of Ferrosilicon.

The British Local Government Board has issued a "Yellow Book," containing a report on the manufacture, uses, and transport of ferrosilicon. The authors are Dr. S. MONCKTON COPEMAN, F.R.S., medical inspector of the Local Government Board; Mr. SAMUEL R. BENNETT, one of the Inspectors of Factories, and Dr. H. WILSON HAKE, F.I.C., chemist.

The report was occasioned by certain accidents during the transport of ferro-silicon, which have been noted several times last year in our columns. The most interesting part of this Yellow Book, however, is probably the description of some details of operation in various European ferrosilicon works which were visited by Dr. Copeman. The chemical tests of Dr. Hake, with respect to the gases evolved, and the various researches on the properties of different ferrosilicons by Mr. Bennett and Dr. Hake also contain much of interest.

Composition of Charge.

Originally the charge of ferrosilicon furnaces was composed of a mixture of (1) iron-pyrites or other form of iron ore; (2) siliceous material in the form of quartzite or sand; (3) carbon in the form of charcoal, coal, or coke, together with (4) some lime as flux. Owing, however, to the obvious impurity (especially high phosphorus and sulphur content) of earlier samples of electric-furnace ferrosilicon, scrap-iron and steel shavings are now preferred to iron ore, and quartzite to sand, as being less productive of obstructions in the furnace. Further, the purer the starting material, the less slag will be formed. The addition of lime seems to have been entirely abandoned as unnecessary; this is of importance, in connection with the problem of the generation of dangerous gases from ferrosilicon (see below).

As the properties of the ferrosilicon produced depend to some extent on the raw materials used, the following details from Dr. Copeman's report on the raw materials used in various European plants will not be wholly without interest.

At the **Bozel** works of La Compagnie Generale d'Electrochemie de Bozel (one of the plants of the old ferrosilicon syndicate) the materials employed are as follows:

Quartz (or rather quartzite) obtained locally, containing in the average 95 per cent silicon, 4 per cent aluminium, with small amounts of calcium and phosphorus, the latter averaging from 0.3 to 0.8 per cent.

Steel turnings, containing not more than 0.3 per cent of phosphorus.

Anthracite coal, which is obtained locally and is cheap, but which yields as high a quantity as 20 per cent of ash.

The grades of ferrosilicon produced at the Bozel works represent percentages of silicon of 25, 50 and 80, respectively. In the manufacture of the 80 per cent grade, however, charcoal, although much more expensive, is employed instead of anthracite coal, on account of its great freedom from impurities.[1]

At the Keller-Leleux works at **Livet** (Isere) there are five 1200-hp Keller furnaces, making a melt of 500 kilograms of ferro-alloy every two hours, and three 500-kw furnaces, with a daily output of 12 melts, each of 2 tons. Not all these furnaces are running.

Actual working results have demonstrated that the energy required for the production of 1 ton 30 per cent ferrosilicon in the electric furnace is 3500 kilowatt hours, and at the Livet works it has been found practicable, with an expenditure of 4000 hp to turn out 20 tons 30 per cent ferrosilicon per day.

The materials employed in the Livet works in the manufacture of ferrosilicon are as follows:

Iron and steel shavings,

[1] As the cost of transport, especially in the mountain districts, constitutes an important factor, the particular form of carbon used depends on the facility with which one or the other kind is obtainable within reasonable distance from the works. In most instances anthracite coal is employed, of which large deposits are worked in the mountainous regions of the southeast of France. But this anthracite is often quite impure. Hence the substitution of charcoal in the manufacture of the higher grades of ferrosilicon.

Quartzite, containing 94 to 96 per cent silica.[2]

Anthracite coal (averaging ash 7 per cent; 0.013 per cent P., 0.41 per cent S, no arsenic).

"Iron and steel shavings, although more expensive, are exclusively used by this firm rather than 'tournures de fonte,' generally employed by other manufacturers for the reason that they contain much less phosphorus—a maximum of 0.10 as against an average phosphorus content of 0.50 to 0.80 for iron turnings."

At the **Giffre** works, St. Jeoire (Haute-Savoie), of the Société Electro-Chimique du Giffre) the constituents of the furnace consist of quartz-rock, anthracite and steel turnings, of which the quartz-rock contains about 96 per cent of silica. The anthracite of good quality from the point of view of small phosphorus content is obtained locally.

At the **Ugine** (Savoie) works of the Société Anonyme Electrometallurgique Procédés Paul Girod, the constituents of the charge are:

Quartzite, containing about 92 per cent of pure silica, with traces only of phosphorus and sulphur.

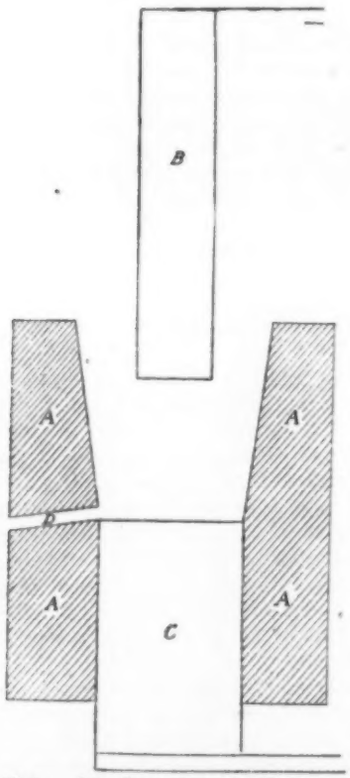
Coal (forging) obtained from St. Etienne—of best quality, and guaranteed not to average more than 8 per cent of ash, or more than .005 per cent of phosphorus or sulphur.

Steel and iron scrap.

At the **St. Marcel** (Savoie) works of the Société d'Industrie Electro-Chimiques La Volta, the charge constituents are:

Quartzite, obtained in the neighborhood of the works, with an average content of 98 per cent of silica, together with traces of magnesia, but no lime.

Gas coke, for production of the 50 per cent grade of ferro-



A—Walls. BC—Electrodes. D—Tapping Hole.

FIG. 1.—FERROSILICON FURNACE. DRAWN TO SCALE.

silicon, while in the manufacture of 25 per cent alloy or other comparatively low grades this is replaced by anthracite coal, which is cheaper, but not so free from impurities.

[2] There seems to be little difficulty in the French plants in obtaining, at a reasonable cost, quartzite or other comparatively pure form of silica, but it generally contains an appreciable amount of calcium phosphate as impurity. This is of importance in connection with the production of dangerous gases from ferrosilicon, as will be shown later on.

Iron-ore (for 50 per cent ferrosilicon) or steel shavings (for lower grades). The iron ore is stated to contain 95 per cent of iron oxide (Fe_2O_3), but no trace of aluminium, manganese or calcium.

The **Wednesfield** experimental station of the British Coalite Company, Ltd., use as constituents of the charge:

(1) Natural sandstone rock.
(2) Pitch, with addition of 10 per cent anthracite coal.
(3) Iron oxide.

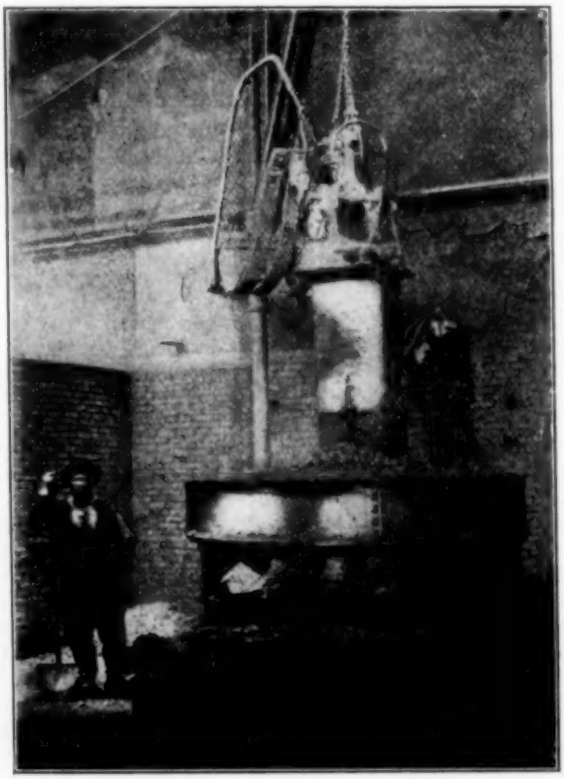


FIG. 2.—FERROSILICON FURNACE AT GIFFRE WORKS.

The sandstone rock, utilized as the source of silica, is of a greyish color, owing to the fact that it is impregnated with about 8.5 per cent of bitumen; in addition to which it contains small quantities of other volatile constituents, including traces of nitrogenous matter. On being heated, it yields a whiteish grey, extremely friable material, small pieces of which can be readily broken down in the fingers to a fine powder, which consists of pure silica to the extent of 99 per cent.

The pitch is obtained as a by-product in the manufacture of coalite. This is used with addition of 10 per cent of its weight of anthracite coal. They would prefer to employ pitch-coke, but this from the electrical point of view would form too good a conductor.

The iron oxide consists of Fe_2O_3 precipitated in the form of a fine powder, which owing to its purplish color is useless as a paint, and so is obtainable at a much lower price than the red oxide. The average of several analyses indicates the presence of 95.4 per cent of pure iron oxide.

In making up the charge, the proper proportions of silica and iron oxide are mixed with the anthracite coal; and the whole bound together into a mass with pitch. After mixing, the volatile hydro-carbons in the pitch are driven off by heating, as the result of which the charge is left in a compact mass, which is broken up into small lumps of a suitable size for use in the furnace.

No flux is employed. The object of using pitch is the double one of ensuring that the carbon should be intimately mixed with the iron-oxide and silica, and of making the whole mass a conductor of high resistance.

Furnace Construction.

Resistance furnaces are used throughout for the manufacture of ferrosilicon.

The furnaces which Dr. Copeman saw in operation at the different works visited were, for the most part, of very similar character and size, the main differences being in the external shape—usually circular (as are all internally), but in one or two instances square in section—in the size and shape of the upper electrode and in the mechanical means adopted for raising and lowering and usually for water-cooling this electrode. The furnaces at the Bozel works are provided with two tapping holes, from which the molten ferrosilicon is run alternately, whereas in the case of the furnaces at other works, one tap hole only is provided.

The furnaces are built up of fire-brick, sometimes lined with "a composition of graphite somewhat similar to that employed in the manufacture of the electrodes," and the exterior of the furnace is usually braced with iron "stays" or completely enclosed in a circular or square iron casing made up of sections bolted together.

Figs. 1, 2 and 3 show different designs of ferrosilicon furnaces. Fig. 1 is a drawing to scale of the usual type of furnace, Fig. 2 is a view of the furnace used at the Giffre works in St. Jeoire, Harte-Savoie, and Fig. 3 shows the design of the Keller furnace.

Except in the case of the furnace specially designed by Keller, of which an outline illustration is given in Fig. 3, the second lower electrode is placed beneath the floor of the furnace, its upper surface being flush with the level of the furnace hearth. At the Giffre works, for instance, this lower electrode is formed in situ by ramming into an open space in the floor of the furnace a mixture formed by heating together powdered retort graphite and coal tar.

The power employed in each furnace ranges from 250 or 300 hp to as much, in some cases, as 750 or 800 hp.

The type of furnace used in the Keller-Leleux works is such as to obviate the use of the furnace hearth as a conductor. Further to ensure the continuity of working, several electrodes are placed in parallel in the system, any one of which is renewable without the necessity of stopping or varying the working of the furnace as a whole. Keller's furnace, constructed on these principles, contains at least two groups of two electrodes each, the two latter being arranged in parallel, and the two groups themselves in series. These four electrodes of equal capacity project through refractory walls, and each electrode is provided with independent mechanism by which it can be raised or lowered at will. The intensity is equalized in each focus of the same group by means of readings taken with an ammeter, and the pressure of the group is controlled by means of two voltmeters inserted respectively between the furnace hearth and each group.

The voltage and amperage employed (the former especially) varied somewhat widely at the different establishments inspected, ranging from 40 to 75 volts, and from 10,500 to 15,000 amperes, respectively.

When once charged and started, the furnaces are run continuously for an average period of a couple of years, although, as stated at the Keller-Leleux works, the period may be extended to as much as four years. While running, the furnaces are tapped at intervals of 1 to 2 hours, the men working in shifts so that the furnaces can be attended to by night as well as by day, fresh amounts of charge being shoveled on the top of the furnace around the upper electrode as often as is rendered necessary by the melting and consequent shrinkage of the underlying mass.

Proportioning of Charge.

The charge is generally made up in proportions according to the formula

$$SiO_2 + 2C = Si + 2Co.$$

so that for every 60 parts by weight of pure silica 24 parts of pure carbon are used. But the making up of a charge is complicated by the fact that each of the three constituents, iron, quartzite and anthracite, notably the anthracite, will certainly contain impurities, the amount of which in each case has, therefore, to be determined and allowed for in the calculation.

This is illustrated by a concrete example, given by M. Barut, administrator of the Giffre Works at St. Jeoire, Haute-Savoie.

The composition of the anthracite coal in use at the time of Dr. Copeman's visit was "roughly" as follows:

Carbon ..... 82 per cent.
Ashes ..... 10 per cent.
Moisture and gases..... 8 per cent.

while analysis of the quartzite showed that it contained about 96 per cent SiO_2.

"Taking, then, the combining weights represented by the equation already referred to, viz:

$$SiO_2 + 2C = Si + 2CO$$
$$60 \quad 24 \quad 28 \quad 56$$

and noting that 24 kilograms of carbon will be represented by 30 kilograms of 80 per cent anthracite, the required proportion of silica to coal will be the simple one of 2:1, on which, however, allowance has to be made for the fact that 100 parts by

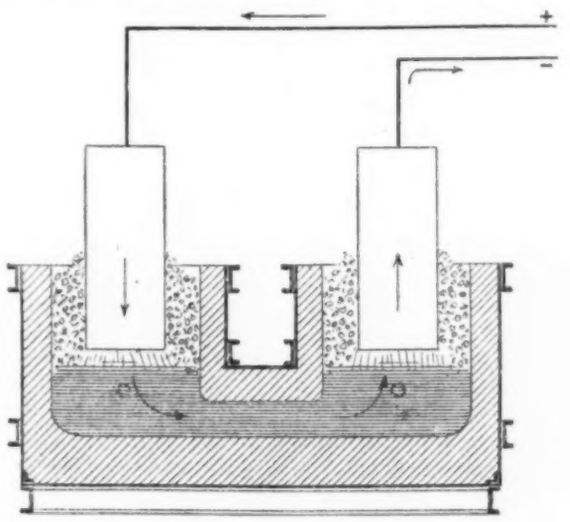


FIG. 3.—KELLER FURNACE.

weight of quartzite contain 96 parts only of silica, or about 144 kg of silica in 150 kg of quartz.

"As regards the source of the iron also, some allowance is of course necessary, seeing that the steel turnings employed will contain a certain amount of iron oxide in addition to small amounts of impurities.

"Taking these different factors into consideration, the respective weights of the several ingredients required to make up a charge for the production of, say, a 50 per cent ferrosilicon, will be as follows:

Quartz.....	150 kg	(= about 144 kgms SiO_2).
Anthracite.....	72 "	(= about 66 kgms Si).
Steel turnings.....	55 "	
	277 kg	

"Dealing with these quantities:

"Sixty-six kilos silicon + 55 kilos steel turnings should theoretically yield 121 kg, all the carbon of the anthracite being given of as CO (carbon monoxide gas). But, as a matter of fact, in addition to the total disappearance of the carbon, a certain proportion of the silicon and iron (about 11 kg on the quantities here dealt with) is also not accounted for in the final product, being presumably lost through incorporation with the slag. Consequently, the amount of alloy actually obtained from the above charge of 277 kg will be 110 kg only of 50 per cent ferrosilicon.

"In the event of a lesser or greater silicon percentage being required, the weight of steel turnings in the charge must be increased or diminished accordingly."

Process of Manufacture.

In practice the requisite amounts of the three ingredients of the charge are weighed out separately, the quartz and anthracite coal having previously been reduced to small fragments of a size varying roughly from that of a filbert to that of a walnut. After weighing, the different materials are thrown together into a heap on the floor of the furnace house where they are mixed as thoroughly as possible with a shovel. The resulting rough mixture is then thrown onto the top of the furnace a shovelful at a time, care being taken to heap it up around the vertical electrode or electrodes, as the case may be.

To receive the molten material when the furnace is tapped, a shallow bed of sand is prepared, either on the floor or, as was the case at one of the manufactories visited, in an iron box on wheels, which accordingly can be removed as soon as the tappings shall have to come to an end. Usually, however, immediately the flow of white-hot liquid has ceased, the surface of the resulting pool of molten alloy is skimmed to remove the layer of slag on the surface, a short, thick log of green wood fixed crosswise on the end of a long iron bar being employed for this purpose at the Keller-Leleux works.

As soon as the cake or slab of ferrosilicon has solidified, it is broken up with heavy iron hammers into comparatively small pieces, which in the case of the 50 per cent grade, at any rate, it has recently become the custom, at several of the works Dr. Copeman visited, to treat, while still hot, by immersing them in a bath of kerosene oil or melted crude paraffin.

This "pickling" treatment has been adopted on the assumption that by thus preventing contact with the air by means of a coating of oil or paraffin, it would prove possible to obviate the well-known tendency of certain samples of 50 per cent ferrosilicon to disintegrate spontaneously, and thus, incidentally, to prevent evolution of noxious gases, mainly phosphoretted and arseniuretted hydrogen, which under certain circumstances appear to be associated in specially large quantity with this particular grade of electrically produced ferrosilicon.

But as regards the prevention of the process of disintegration, the precise causation of which, by the way, is still to seek, the kerosene or paraffin bath treatment has not proved successful; while the fumes given off when ferrosilicon, which has been "coated" after this fashion, is subsequently heated, as appears to be considered before being utilized for its specific action on addition to a bath of molten steel or iron, are most objectionable, owing to the crude material usually employed. In addition, the heating of the alloy thus rendered necessary before use at ironworks must obviously promote in special degree the evolution of poisonous gases, and thus prove a special source of danger to workmen engaged in handling the material, and to whom this preliminary treating of the alloy is entrusted

In view, therefore, of the complete futility of this process of "pickling" for the intended purpose, coupled with the fact that it may actually involve, later on, an added source of danger to workers in the iron foundries, it is certainly desirable that the method should be abandoned.

Evolution of Gases from Ferrosilicons.

Concerning the evolution of obnoxious or dangerous gases from ferrosilicon under the influence of moist air, especially when accompanied by friction, Dr. H. Wilson Hake states in his report that the following gases have been alleged to be evolved: Phosphoretted hydrogen (PH_3), arseniuretted hydrogen (AsH_3), siliciuretted hydrogen (SiH_4), acetylene (C_2H_2), and hydrogen. In the numerous samples which he has examined, he has not found, however, any acetylene or siliciuretted hydrogen, and he does not believe they are evolved. All his evidence seems to show that the poisonous emanations evolved from ferrosilicon by the action of water consist mainly of phosphoretted hydrogen; sometimes alone, but for the most part accompanied by varying proportions of arseniuretted hydrogen.

The formation of these gases is due to the presence of small quantities of certain impurities in the coal, iron and quartz, used as starting materials; and in this respect the most important impurities are calcium phosphate and arsenic.

Calcium phosphate $Ca_3(PO_4)_2$ one of the impurities present in coal and in quartz, which in itself is a perfectly harmless salt, insoluble in water and widely diffused in nature, is responsible for the production of a dangerous compound by reduction in the electric furnace, in the presence of carbon, to calcium phosphide (Ca_3P_2).

This calcium phosphide remains in the ferrosilicon, and in contact with water or moist air is decomposed with evolution of phosphoretted hydrogen (PH_3), with an intensely poisonous character.

Arsenic again, an element closely allied with phosphorus in its properties, is another impurity liable to be present in various combinations in coal and in iron, and this element also finds its way into the ferrosilicon apparently as calcium arsenide. Calcium arsenide is also decomposed by water or moist air, evolving arseniuretted hydrogen (AsH_3), a gas scarcely, if at all, less poisonous than phosphoretted hydrogen.

Specific Gravity of Ferrosilicons.

The variations of hardness and of specific gravity of alloys containing different percentages of silicon are quite characteristic and may be used as a rough indication of the approximate composition.

The specific gravity decreases as the percentage of silicon increases, which obviously follows from the fact that the specific gravity of pure iron is 7.8 while that of pure silicon is 2.49.

Fig. 4 gives the results of Dr. Hake's determinations of the specific gravity of various samples of commercial ferrosilicon in comparison with the theoretical curve (the thick line in Fig. 4) representing the calculated specific gravities for all percentages on the assumption that mixtures of iron and silicon are formed without change of volume.

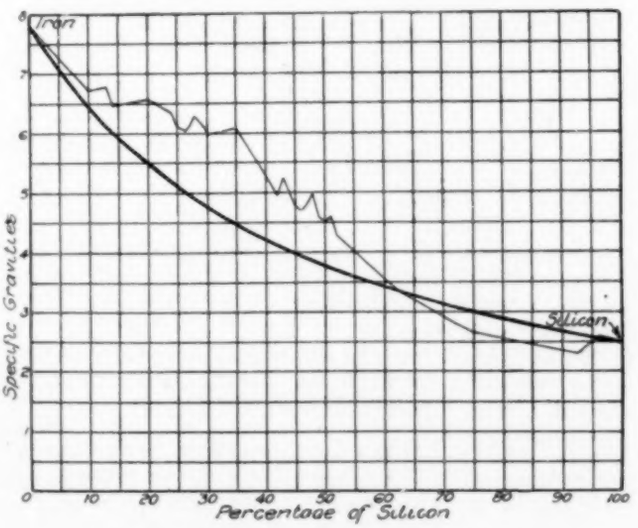


FIG. 4.—SPECIFIC GRAVITY OF FERROSILICON.

A comparison of the two curves demonstrates, what is indeed already well known, that such is not the case and the specific gravities are partly above and partly below the theoretical curve, showing that contraction of volume has occurred in the alloys formed up to 60 per cent silicon and expansion of volume from this to 96 per cent silicon, presumably owing to the presence of definite silicides of iron in the alloys.

Microstructure.

Mr. Samuel R. Bennett's report gives further confirmation of the general character of the specific gravity curve and also discusses the microstructure of ferrosilicons. Fig. 5 is Guertler and Tammann's diagram. Mr. Bennett gives some interesting microphotographs of various ferrosilicons and then sums up his conclusions as follows:

The various percentage grades of ferrosilicon are substantially binary alloys.

Two compounds, Fe_2Si and FeSi, exist; the former corresponding to 20 per cent Si, and the latter to 33.3 per cent Si, by weight. Microstructure also indicates the existence of two

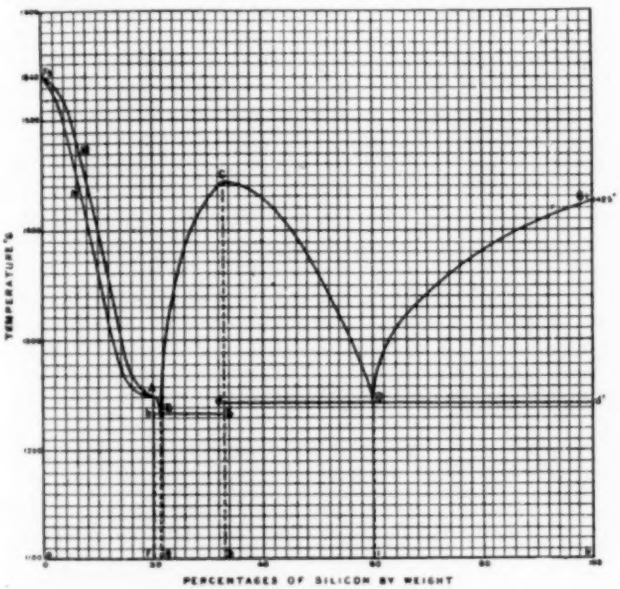


FIG. 5.—FERROSILICON DIAGRAM.

eutectics, one consisting of Fe Si and FeSi, corresponding to 21.6 per cent silicon approximately, and the other consisting of FeSi and Si at 60 per cent silicon.

Investigation of the specific volumes of various grades of alloys does not indicate the presence of other compounds.

Up to 20 per cent Si the alloys consist of solid solutions of Fe and Fe_2Si which are hard, firm masses giving off little or no gas. Alloys from 20 per cent Si to 21.6 per cent Si consist of primary crystals of Fe_2Si in ground of eutectic composed of Fe_2Si and FeSi; these alloys begin to get more brittle than the lower grades. From 21.6 per cent Si to 33.3 per cent Si the structure shows FeSi surrounded by eutectic Fe_2S and FeSi; from 33.3 per cent to 60 per cent Si there are crystals of FeSi in eutectic FeSi + Si; and above 60 per cent Si crystals of Si in field of eutectic FeSi and Si.

The amount of gases given off by different grades of ferrosilicon depends not only on the impurities present in the materials used in the electric furnaces, but also in the physical properties of the alloys, in consequence of which, in certain cases, access of moisture is afforded to a much larger extent of surface.

Hardness.

By the term "hardness" Dr. Hake implies the resistance offered to mechanical disintegration, or in other words, the varying difficulty experienced in breaking up and powdering the samples. To give two extreme instances, a sample with 26.5 per cent Si required a steel ore-crusher to break it up before it could be powdered, while a sample with 50 per cent Si could be crushed between the fingers.

Up to 30 per cent silicon content, the samples are more or less refractory without exception. There is an absence of any tendency on the part of these grades of ferrosilicon to disintegrate spontaneously.

Similarly, from 70 to 96 per cent where the silicon is in excess, although the samples are more or less brittle, they are not so easy to break up and to reduce to powder as those containing between 42 and 60 per cent silicon, and they also do not show a tendency to disintegrate spontaneously.

On the other hand, the samples containing from 42 to 60 per cent show a distinct tendency to spontaneous disintegration. They crumble on keeping, and some of them actually fall to powder after the lapse of a few weeks or months. This spontaneous disintegration is usually accompanied by a very noticeable evolution of evil-smelling and poisonous gases.

It has been alleged that the same phenomenon is apt to occur with 33 to 35 per cent grades, but Dr. Hake has no personal experience of the fact.

Transport and Storage of Ferrosilicon.

In view of the accidents which had happened, four of the large ferro-alloy manufacturers of France (Giffre, Girod, Keller-Leleux, La Volta) formed a special committee which came to the conclusion to propose "to give up making dangerous grades completely, which now are known to be those ranging from 30 to 40 per cent, and from 47 to 65 per cent."

"By discarding these specially dangerous grades and ceasing the manufacture of 30 to 40 per cent and 47 to 65 per cent ferrosilicon, there would remain nothing but perfectly compact alloys as free from danger to transport and to warehouse as ordinary pieces of cast iron."

These recommendations have been accepted by eight other French manufacturers, so that in all 12 French firms have agreed upon the above recommendations.

Dr. Copeman for the British Government Board goes even further in his recommendations. He is of the opinion that "the conclusion is justified that the manufacture of ferrosilicon should, at present, be restricted to the production of percentage grades of 70 per cent and upward at one end of the scale; and, at the opposite extremity, up to and including 30 per cent, on the supposition that under certain circumstances the employment of a comparatively low grade may be desirable or necessary. . . .

"But as, pending international agreement on the question, intermediate percentages of ferrosilicon will doubtless continue to be manufactured and sold, the issue, by the Board of Trade, of special regulations will be necessary in order to obviate, so far as may be possible, chance of further accidents during the transport of this substance."

The following regulations are suggested by Dr. Copeman:

"1. Ferrosilicon should not be sent out from the works immediately after manufacture, but, after being broken up into pieces of the size in which it is usually sold, should be stored under cover, but exposed to the air as completely as possible for at least a month before being dispatched from the works.

"2. Manufacturers should be required to mark in bold letters each barrel or other parcel of ferrosilicon with the name and percentage grade (certified by chemical analysis) of the material; the name of the works where it is produced; the date of manufacture, and date of despatch.

"3. The carriage of ferrosilicon on vessels carrying passengers should be prohibited. When carried on cargo boats, it should, if circumstances permit, be stored on deck. If it be considered necessary to store it elsewhere, the place of storage should be capable of being adequately ventilated, and such place of storage should be cut off by airtight bulkheads from the quarters occupied by the crew of the vessel.

"4. This regulation should apply to the transport of ferrosilicon on river or canal barges as well as on sea-going vessels.

"5. Storage places at docks or at works where ferrosilicon is used should have provision for free access of air, and should be situated at a distance from workrooms, messrooms, offices, etc.

Elsewhere in his report, Dr. Copeman makes the following remarks, which may be mentioned in this connection: "So far

as I am aware ferrosilicon is no longer packed in closed iron drums, so that, to this extent, likelihood of explosion is avoided, but as in transport, even when packed in wooden barrels, a considerable amount of friction must inevitably occur between the rough lumps, in which form the ferrosilicon is ordinarily sent out from the works, I would offer the suggestion that, in the course of packing the alloy into barrels, all interstices might usefully be filled in with shavings, wisps of hay, or other similarly cheap material."

A brief comment on the situation of the ferrosilicon industry in this country will be found on our editorial pages.

On the Preponderance of Nullovalent Matter.

By Dr. Gustavus Hinrichs.

For more than a thousand years chemists of all schools and creeds have experimented on all sorts of ponderable matter under all conditions conceivable, without ever meeting any form of matter which resisted all means of producing chemical changes.

Chemists have, therefore, concluded that all ponderable matter is chemically active, and can, with greater or less readiness, be subjected to entire cycles of chemical transformations, producing more and more complex substances in ascending cycles and obtaining finally, by descending cycles, ponderable matter in the simplest form known, namely, the chemical elements.

Hence chemists have, during the last two centuries at least, held that all ponderable matter is chemically active, and that the chemical elements are simple and irreducible substances.

Two New Fundamental Conclusions.—For more than half a century I have recognized the latter conclusion to be erroneous and for more than a third of a century I have found that the first conclusion cannot be true, and that on the contrary we shall have to admit:

I. Ponderable matter is not chemically active except under very special forms, affecting at most a hundredth of all matter.

II. Matter is one; hence the chemical elements are not simple substances, but combinations of several degrees of one single substance, the Pantogen.

This latter conclusion I have tried to demonstrate in my publications for now more than half a century.

As to the first conclusion, it is known since 1894 that there exist small amounts of a few nullovalent chemical elements. This is the argon group, or argonoids, comprising: Helium, neon, argon, krypton and xenon. The so-called emanation of radium is also nullovalent; but is of an entirely different order, as we expect to show shortly.

Still it remains generally understood that these nullovalent elements are exceedingly rare, though they seem to be widely diffused.

Accordingly, the exception from the old rule, that all ponderable matter is chemically active, appears to be quantitatively of little importance, though sufficient to prove that the old conclusion is not absolutely correct.

So far as we ourselves are concerned, the discovery of nullovalent elements had been expected for more than twenty years; for we have published it implicitly in our Molecular Mechanics, Davenport and New York, 1874; see section XVIII: The Element Atom an Atom Crystal, pp. 178-182.

The Nullovalent Elements in 1874.—In the work of 1874 specified, the four elements Fl, O, N, C are (p. 180-181) compared with the simple organic radicals, CH_3, CH_2, CH, and the tetravalent C, as derived from the saturated (nullovalent) methane CH_4, according to their atomic weight a and their valence n.

"If we generalize this, we can express the atomic weight a of these elements by the formula

$$a = 2\,(10-n) = 20 - 2n$$

"Valence	$n=$	1	2	3	4
Calc. at weight.....	$a=$	18	16	14	12
Obs. at weight.....		Fl—1	O	N	C"

"502.—Now, this corresponds exactly to the organic radicals—namely, if we start from the saturated methane, $CH_4 = 16$, we have $a = 16 - n$, namely,

Atomicity	$n=$	1	2	3	4
Atomic weight	$a=$	15	14	13	12
Radicals		CH_3	CH_2	CH	C

"It is evident that the graphical symbols (Fig. 1, line F, Plate I) might completely represent the above elements, if the *dot* stands for two—i. e., four pantogen atoms * * * while the *cross* stands for twelve, some aggregation of pantogen atoms in the shape of a square prism for one end of which one of the four corners has been removed. It will be seen that this not only accounts for the atomic weight, but also for the atomicity of these most important elements."

In paragraph 503 of the same work, the probable structure of the sulphoids (O, S, Se, Te) is given; in 506 that of the Kaloids (Li, Na, Ka, Rb, Cs), while in 504 the increase 16 is defined, and 505 gives the general law of the addition by 3 times, 3 times, 2 times, 3 times, in the three highest members of each genus of elements and the explanation of the fact exactly as we have given it in our latest publication on this subject: The Proximate Constituents of the Chemical Elements, 1904. These references will be sufficient at this time and in this brief note.

The parallel between the elements and the organic radicals being complete, it is implied that a nullovalent element must correspond to the saturated CH_4, especially as the formula includes the elements of opposite (negative) valence, namely:

Valence	$n=$	—1	—2	—3	—4
Calc. atomic weight....	$a=$	22	24	26	28
Observed		Na—1	Mg	Al—1	Si

These two groups of four each of chemical elements must therefore be connected by a nullovalent element of the atomic weight of 20. This element is known as Neon.

The case is much stronger still. For if we subtract from the constant 20 the common rise of 16 in the atomic weight of the consecutive groups, we obtain the corresponding formula

$$a = 4 - 2n$$

giving the values,

Valence	$n=$	—1	—2	—3	—4
At. wght. calc.....	a=	6	8	10	12
At. wgt. observed.....		Li—1	Be—1	Bo—1	C

and requiring a nullovalent element for $n = 0$ of the atomic weight 4. This evidently is our helium.

These relations contained in my formulæ and figures printed in the work of 1874, as quoted, were quite familiar to me and their bearing was well understood; but it was absolutely impossible, at that time, to state my conclusion. In fact, I shall mention, my experience in 1908 proved that I was too hasty even then, when I was ready to furnish positive proof, as we shall see soon.

What I dared to proclaim in 1874 was more than the chemical public could take; only Berthelot requested me to furnish him certain specified portions of that work for publication in the *Annales de Chimie et Physique*. This was not done, because my time was in 1875 so fully taken up by the collection and study of the Amana Meteorites.

I will mention just one striking experience, which made me hesitate to give further early details of my investigations. My Atommechanik of 1867 was denounced in the *English Weekly Chemical Journal* by the editor, who had never seen the work. It is evident from his statements, he had only the English Resumé, and devoted most of his attention to the historic introduction which is no part of the work itself. Some critics are in every way more free to move the less they are loaded with knowledge of their own and the less they have seen of the work they want to condemn.

It is precisely this condition of things that has now come home to their readers and subscribers, who have been kept in the dark about what has been done, greatly to their disadvantage, even in their own investigations.

Upon the publication of the discovery of Argon in 1894, I

exposed the above relations in a special public lecture, and predicted that it would be but the first of that entire group of nullovalent chemical elements implicitly contained in my Molecular Mechanics of 1874.

The first time I explicitly mentioned my principle of the high preponderance of nullovalent matter over chemically active matter in Nature was in a letter of April 15, 1908, to a prominent chemist of Paris. That chemist never inquired further about it.

The Nullovalent Matter of the Chemically Active Elements.—The formula and figures published by me during the past half century show plainly that the element atoms of a group or Genus have a common active head, and differ only in the growth attained in their bodies, which growth goes by regular additions of very nearly $a:3a:3a:6a$, if the element belongs to what I term heavy or common elements. In the lighter elements, the additions are $a:a:3a:3a:6a$. In all cases, a is nearly 16.

These statements may be verified by an examination of my Principles of Chemistry and Molecular Mechanics of 1874; the Pli-Cacheté of 1891 (published, 1907); True Atomic Weights of 1894, and The Proximate Constituents of the Chemical Elements, of 1904. All my deductions of the physical, chemical and crystallographical properties of the elements are based upon this general structure. We can not go into further details here.

Since the chemical character of an element depends on the head only, all these additions are chemically inert or nullovalent. That is: in the Kaloids, the chemically active matter can not be more than what there is of it in an atom of Lithium. But by no means is all the weight of a lithium atom chemically active.

By my recent researches I have been able to prove that, in a hydrogen atom, the chemically active part is less than 1 per cent (*Comptes Rendus*, T. 147, pp. 797-800, 1908).

This percentage is not likely to be greater in an atom of lithium (as a matter of fact, it is demonstrated now to be much less than 1 per cent). Since the chemically active part in all kaloid atoms is the same, it cannot be more than 7/23, say 1/3 per cent in Na; 7/39 or 1/6 per cent in Ka; and not more than 1/20 per cent or half a pro mille in Cesium.

In other words: the total amount of chemically active matter is much less than 1 per cent of the total ponderable matter in existence. That is: chemically nullovalent matter is not an insignificant small fraction of the ponderable matter of the universe, but constitutes more than 99 per cent of all matter.

After waiting more than thirty years before speaking of this decidedly strange result, I found that I had been altogether too hasty. The details of this, my experience, are quite interesting to me and are likely to be so to others in a near future; but we have no place for them here and now.

Right here and just now the reader will possibly say that I have not proved my statements about the great predominance of chemically inert matter over the chemically active ponderable matter. I fully sympathize with the reader; for I know exactly what is the difficulty in his way, and will do all I can to clear the road.

First, the reader is in the position of a student listening to a demonstration of a geometrical proposition while not familiar with geometry; he cannot see the force of the demonstration.

Now, in that sort of a case, I have found it quite useful to show by some simple measurements or weighings, on models, that the proposition holds good in such special cases.

I shall do that very thing in a concluding article next month, in which I shall determine the weight of the amount of active matter in the atom of silver and of other chemical elements, which alone is characteristic of its chemical activity.

In the meantime I would respectfully request the reader of the present note to lay this paper aside, and to read it very carefully once every week till the next issue comes to hand; I dare say that the reader will gradually feel at least some of the force of the reasoning here employed.

By this process the reader will also have prepared himself for the more ready understanding of the mode of calculation that will be used in the closing paper.

Just think for a moment on the difficulties in the way of understanding the form of the earth and the position of the antipodes—a thousand years ago. In science we have to wrestle with such apparent difficulties at every big step we take forward into greater light.

ST. LOUIS, MO.

Pulp Classification and Tube Mill Efficiency.

In an interesting paper presented to the Mexican Institute of Mining and Metallurgy (Informes y Memorias del Instituto Mexicano de Minas y Metalurgia, Vol. 1, No. 3, December, 1909), Mr. V. B. SHERROD reports on some features of the extended research work which has been done at the Guerrero Mill, Pachuca, Mexico, particularly in the direction of pulp classification and in ascertaining the efficiency of tube-mill work under varying conditions.

The flow-sheet on page 140 illustrates clearly the sequence of the various operations and is self-explanatory.

Table I, "Screen Analysis of Samples," shows the average screen, or grading analyses of several sets of samples taken during the month of July, 1909, at the Guerrero Mill, the various products at each step being carefully sampled. A study of the figures will show some very interesting features.

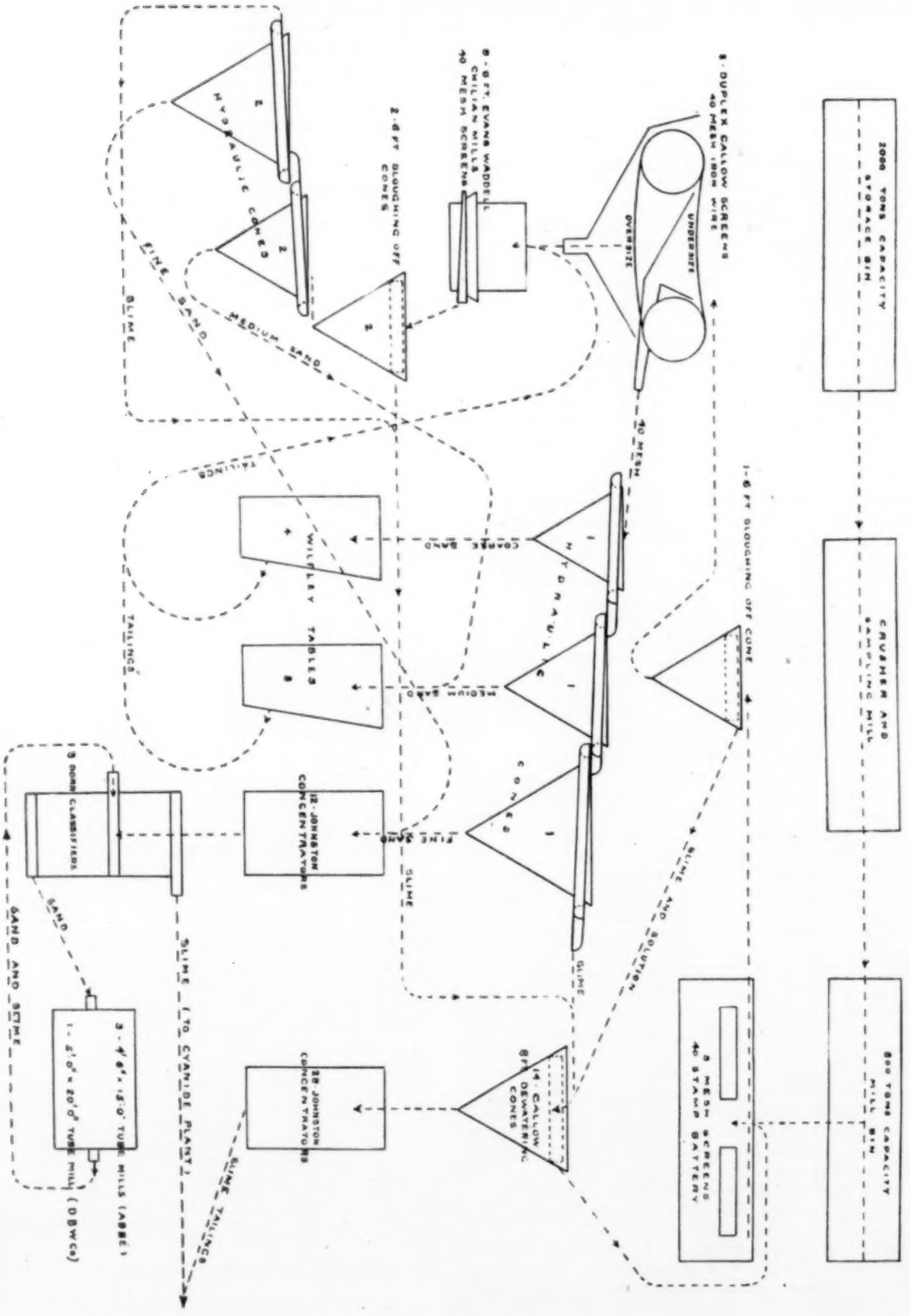
Special attention is called by Mr. Sherrod to the work of the Callow screens, which at 100 ft. belt travel per minute (a very high speed) when equipped with 30-mesh, No. 33 steel wire (the purpose being to separate as undersize all material that can be made to pass a 40-mesh laboratory screen) gives an oversize 92 per cent of which remains on a 40-mesh screen and 96.5 per cent remains on 60-mesh screen. At the same time an undersize is sent to the hydraulic cones, 9½ per cent of which passes a 40-mesh, said product containing practically all of the liberated mineral. The effect of this system is seen in the enormously wide streak of mineral on the first three Wilfley tables, which really receive as feed a product that has once been concentrated by the Callow screens and once by the hydraulic cones following these.

Another feature of interest to concentrator men is the analysis of the product of the Chilean mills, 4 per cent of which remains on a 40-mesh screen and 32.4 per cent of which passes a 200-mesh screen notwithstanding that a 30-mesh "ton-cap" screen is used in the mills. The discharge through these screens is kept up to the maximum, a heavy splash being used, but all material coarser than 60-mesh is, so far as possible, cut out in the first hydraulic classifiers following these mills and sent back to the Wilfley tables, where it joins the oversize from the Callow screens and returns again to the Chilean mills.

Another feature of the grinding at Guerrero Mill is the fineness of the tube-mill feed, only 7 per cent of which remains on a 60 screen. This is, of course, absolutely against high tube-mill tonnage, but is justified by the necessity for the most careful possible concentration, which means on these ores pretty fine grinding (in stages) and careful elimination after each step and before the tube mills get a chance to slime the mineral. The apparently low efficiency of the tube mills receiving such feed (in comparison with, for instance, the Loreto Mill of the same company, in which a much simpler flow-sheet is in use) is principally due to the fact that all of the easily slimed portion of the ore has been made to pass a 200-mesh screen during its repeated passage through the Waddell mills, leaving for the tube mills nothing but the most refractory portion to grind.

Tube Mill Operations, Screen Analysis of Feed and Discharge.

The Table II is made up from sampling done at Loreto Mill on various dates, and does not furnish absolute comparison with the performance of the Waddell mills above mentioned, on account of the difference in grinding systems employed and also


2000 TONS CAPACITY STORAGE BIN
CRUSHER AND SAMPLING MILL
800 TONS CAPACITY MILL BIN
8 DUPLEX CALLOW SCREENS 40 MESH IRON WIRE
OVERSIZE
UNDERSIZE
8 - 6 FT. EVANS WADDELL CHILIAN MILLS 40 MESH SCREENS
2 - 6 FT SLOUCHING OFF CONES
HYDRAULIC CONES
FINE SAND
SLIME
MEDIUM SAND
TAILINGS
40 MESH
1 - 6 FT SLOUCHING OFF CONE
WILFLEY TABLES
HYDRAULIC CONES
SLIME AND SOLUTION
12 - JOHNSTON CONCENTRATORS
14 - CALLOW DEWATERING CONES
8 MESH SCREENS 40 STAMP BATTERY
15 DORR CLASSIFIERS
SAND
SLIME (TO CYANIDE PLANT)
SAND AND SLIME
3 - 4' 6" x 18' 0" TUBE MILLS (ABBE)
1 - 5' 0" x 20' 0" TUBE MILL (DBWC)
SLIME TAILINGS

FLOW-SHEET

TABLE I—SCREEN ANALYSIS OF SAMPLES

		Per Cent. Solids	Percentage on Screens								
			+10	+20	+40	+60	+80	+100	+120	+150	+200	−200
Battery discharge		20.74	36.0	20.0	16.4	6.8	2.6	3.6	.5	2.0	1.8	10.3
Elevator No. 1, Sloughing-off-cone	Overflow	3.59	....	....	....	....	....	.5	.1	2.5	4.9	92.0
	Spigot	30.85	35.8	20.1	17.0	7.5	3.0	3.9	.8	2.5	2.0	7.4
Callow-Screens	Oversize	35.50	43.0	27.0	22.0	4.5	1.5	.5	....	.3	.1	1.1
	Undersize	11.92	....	....	8.8	23.7	12.0	14.7	2.0	7.0	6.0	25.8
Wilfleys, pulp from Callows	Feed	18.00	....	....	8.7	28.0	14.8	16.3	2.9	7.8	5.5	16.0
	Discharge	9.33	....	....	8.6	28.1	15.0	16.2	2.8	7.5	5.9	15.9
Wilfleys, Chilean Return	Feed	20.35	....	....	11.5	44.0	16.3	12.3	2.5	4.2	2.5	6.7
	Discharge	11.37	....	....	12.0	44.0	16.0	12.0	2.5	4.1	2.6	6.8
Wilfley Tables, General	Feed	18.94	....	....	11.6	37.0	15.0	14.7	1.6	5.1	3.9	11.0
	Discharge	11.87	....	....	11.7	36.9	15.2	14.8	1.5	5.0	4.0	10.9
Waddell Mills	Feed	22.46	19.5	11.4	16.0	24.5	9.6	8.2	1.0	4.0	2.2	3.6
	Discharge	22.60	....	....	4.0	23.8	12.7	14.5	1.2	6.8	4.6	32.4
Elevator No. 3, Sloughing-off-cone	Overflow	4.41	....	....	....	.2	.4	.5	.1	.8	1.5	96.5
	Spigot	25.93	....	....	6.4	28.5	13.2	14.5	2.0	8.2	4.5	22.7
Elevator No. 4, Sloughing-off-cone	Overflow	4.49	....	....	....	.3	.5	.4	.1	1.5	3.7	93.5
	Spigot	27.58	....	....	7.5	29.6	13.0	15.9	2.5	8.8	3.5	19.2
60-inch, No. 1 Classifier	Overflow	5.59	....	....	....	.8	.9	1.0	.5	2.6	3.3	90.9
	Spigot	17.90	....	....	.6	12.0	10.5	18.7	4.8	10.0	8.0	35.4
60-inch, No. 2 Classifier	Overflow	6.09	....	....	....	.9	1.0	1.1	.5	2.5	4.0	90.0
	Spigot	24.02	....	....	.5	14.3	12.9	21.4	2.7	12.9	9.8	25.5
Johnstone Slime Tables	Feed	13.52	....	....	....	.1	.2	.4	.1	2.5	3.2	93.5
	Discharge	9.53	....	....	....	.1	.3	.3	.1	2.6	3.2	93.4
Johnstone Fine Sand Tables	Feed	18.75	....	....	.5	13.2	11.5	20.4	3.0	12.2	10.5	28.7
	Discharge	14.21	....	....	.4	13.1	11.3	20.3	3.1	12.1	10.7	29.0
Dorr Classifiers	Feed	32.94	....	....	.5	6.9	8.3	22.5	3.7	18.8	13.1	26.2
	Slime Overflow	12.15	....	....	....	....	.1	2.5	1.0	9.5	11.0	75.9
	Sand Discharge	60.47	....	....	.5	7.7	.2	26.0	5.0	23.8	13.5	14.3
Tubemill No. 1, 4'6" by 15' Abbé	Feed	59.76	....	....	.5	7.3	11.0	25.0	4.5	23.5	13.1	15.0
	Discharge	60.90	....	....	....	3.3	6.5	21.7	4.7	22.6	13.5	27.7
Tubemill No. 2, 4'6" by 15' Abbé	Feed	60.00	....	....	.4	7.7	10.7	27.8	5.0	20.8	12.8	14.8
	Discharge	61.32	....	....	....	2.3	5.5	20.6	4.7	20.0	15.0	31.9
Tubemill No. 3, 4'6" by 15' Abbé	Feed	58.64	....	....	.5	7.5	11.9	26.5	4.4	22.0	12.5	14.7
	Discharge	59.34	....	....	....	3.7	6.7	23.2	3.1	21.2	14.2	27.9
Tubemill No. 4, 5' by 20' D. E. W. C.	Feed	59.84	....	....	.5	8.5	10.0	26.0	4.5	24.1	12.8	13.6
	Discharge	60.87	....	....	....	3.1	7.2	22.7	4.7	23.0	12.5	26.8
General	Slime to Tanks	10.60	....	....	....	....	....	2.0	.2	6.6	8.1	83.1

because the ores fed to these mills are much more friable than those ground in the Guerrero mill. The object of the test was to determine the most efficient feed for the tube mills and to furnish comparison between the tube mills differing from each other in make and leading dimensions, especially diameter.

The samples from which the analyses were obtained were taken in sets, and for obvious reasons, such as daily variations in the character of the ore, etc., too close comparisons should not be made between analyses of samples of different sets. Some sets of samples must also be eliminated from any comparisons whatever, because conditions changed so frequently during the two or three hours consumed by the tests that determination of kilos per minute of solids fed to mill, percentage of solids, etc., are not accurate. Such tests are indi-

TABLE III.—SCREEN TESTS OF WADDELL CHILIAN MILLS

OBJECT OF TEST—TO DETERMINE EFFECT ON EFFICIENCY OF VARIOUS FEEDS

Test	Date	Solids in Feed	Dry Ore Per Minute	Water Per Minute	P	+10	+20	+40	Ground Through 40		+60	Ground Through 60		+80	Ground Through 80	
		Per Ct.	Kilos	Kilos		Per Ct.	Per Ct.	Per Ct.	Per Ct.	Kilos	Per Ct.	Per Ct.	Kilos	Per Ct.	Per Ct.	Kilos
1	7/3	13 11	24	159	35	39	11 7	12 5	....	....	16 4	....	....	9 0	....	....
		....	....	....	....	....	....	7 0	56 2	13 5	18 6	54	12 9	13 5	49 5	11 8
2	"	27 7	56	146	41	35	14 0	19 0	....	....	14 6	....	....	7 0	....	....
		....	....	....	....	....	....	5 0	63 0	35 3	19 5	58 1	32 5	15 5	49 6	20 8
3	"	21 5	70	256	48	37 0	13 0	15 6	....	....	15 8	....	....	8 5	....	....
		....	....	....	....	....	....	6 0	59 6	41 7	19 0	56 4	39 48	14 0	50 9	35 6
4	"	24 4	62	192	44	36 0	12 9	18 8	....	....	15 6	....	....	8 3	....	....
		....	....	....	....	....	....	5 8	61 9	38 4	19 2	58 3	36 1	14 5	52 10	32 30
5	"	22 3	80	278	50	30 0	16 0	16 0	....	....	17 2	....	....	9 0	....	....
		....	....	....	....	....	....	8 6	53 4	42 7	18 4	52 2	41 8	14 2	47 2	37 8
6	"	9 9	34	310	35	35 3	17 5	15 0	....	....	13 1	....	....	7 0	....	....
		....	....	....	....	....	....	5 0	62 8	21 35	18 7	57 2	19 45	14 2	50 0	17 0
7a	"	13 6	40	254	38	32 0	10 0	15 6	....	....	20 2	....	....	9 8	....	....
		....	....	....	....	....	....	6 2	51 4	20 6	21 0	50 6	20 2	16 2	45 8	18 3

Test	+100	Ground Through 100		+120	Ground Through 120		+150	Ground Through 150		+200	Ground Through 200		−200	Ground Through 200		Kilos Through 200 Mesh O/ H.P. O/ Min
	Per Ct.	Per Ct.	Kilos	Per Ct.	Per Ct.	Kilos	Per Ct.	Per Ct.	Kilos	Per Ct.	Per Ct.	Kilos	Per Ct.	Per Ct.	Kilos	
1	4 4	....	....	0 5	....	....	2 0	....	....	1 4	....	....	2 9	....	....	....
	12 2	41 7	10 00	2 2	40 0	9 6	7 10	34 9	8 37	8 3	28 0	6 7	30 8	27 9	6 69	0 19
2	4 0	....	....	0 2	....	....	1 6	....	....	1 0	....	....	3 3	....	....	....
	11 5	42 1	23 6	2 0	40 3	22 6	6 9	35 0	19 6	7 2	28 8	16 1	32 0	28 7	16 1	0 39
3	4 7	....	....	0 1	....	....	1 9	....	....	1 8	....	....	1 4	....	....	....
	12 5	43 1	30 2	2 1	41 1	28 8	7 5	35 5	24 8	7 9	29 4	20 6	30 6	29 2	20 4	0 42
4	5 0	....	....	0 3	....	....	1 2	....	....	0 8	....	....	1 0	....	....	....
	12 0	45 1	27 9	2 4	43 0	26 7	7 0	37 2	23 1	7 8	30 2	18 7	31 0	30 0	18 6	0 42
5	5 1	....	....	0 2	....	....	2 0	....	....	1 9	....	....	2 5	....	....	....
	13 2	39 1	31 3	2 6	36 7	29 4	7 0	31 7	25 4	6 6	27 0	21 6	28 9	26 4	21 1	0 42
6	4 9	....	....	0 4	....	....	2 1	....	....	1 0	....	....	3 1	....	....	....
	12 0	43 9	14 9	2 3	42 0	14 2	7 0	37 1	12 6	6 8	31 3	10 6	33 2	30 1	10 2	0 29
7a	6 0	....	....	0 5	....	....	2 2	....	....	1 6	....	....	1 6	....	....	....
	14 1	37 7	15 1	2 1	36 1	14 4	7 1	31 1	12 5	6 5	26 3	9 5	26 5	24 9	10 0	0 26

a This mill was equipped with wornout rings from other mills.

cated by marginal notes. Despite these disabilities, however, it was possible to collect much valuable data.

The determination of the most favorable feed for horse-power efficiency was naturally the first consideration, with special reference to the percentage of solids in the feed and the kilos of dry feed per minute for each different mill. A little study of the table leaves no doubt as to these points, except in the case of No. 4 mill (D. E. W. Company, 5 ft. x 20 ft.) wherein the value of these tests was practically destroyed by the variations of feed above referred to. Therefore, the tests on this mill are given for what they are worth, demonstrating as they do the horse-power efficiency of the mill does not increase with the quantity of dry feed up to an undetermined point.

Briefly, the conclusions which may be safely drawn from the series of tests are as follows:

1. That the grinding efficiency increases with the percentage of solids in the feed up to approximately 55 or 60 per cent.

2. That the grinding efficiency increases with the quantity of ore fed per minute to a point which varies with the dimensions of the mill, and that beyond this point capacity is not gained, and within reasonable limits there is no loss except that due to the return to the mill of an excess of oversize.

The limit of profitable feed varies with the character of the pulp, and it is only possible to determine this limit for any mill by special experiment with the ores for which the mill is intended.

At the Loreto mill the profitable feed for the 4-ft. x 18-ft. mill was apparently 80 kilos of solids per minute, or at the rate of 115 metrical tons per 24 hours, although heavier feed did not reduce the efficiency of the mill. The limit for the two 4-ft. 6-in. x 15-ft. mills was not proved, but is apparently somewhat lower than the correct feed for No. 1 and is probably due to the

TABLE II—SCREEN ANALYSES OF TUBE MILL FEED AND DISCHARGE

Mill Material		1909	Per Cent. Solids	K's Per Minute		Screen Analyses								K's per Min. Through 200 Screen	H. P.	Kilos per H. P. per Min. Through 200
				Solids	Solution	+40	+60	+80	+100	+120	+150	+200	−200			
1 Krupp: 4′×18′–31 R. P. M.	Feed	3/23	55.0	....	....	0.2	5.0	5.7	14.2	2.3	20.0	19.8	33.5	....	....	....
	Discharge	"	55.3	....	....	....	0.2	0.6	5.5	2.0	11.7	15.1	63.1	....	....	....
2 Abbé: 5′×15′–29 R. P. M.	Feed	"	60.3	....	....	0.3	5.2	6.6	14.0	2.9	20.7	19.1	30.3	....	....	....
	Discharge	"	60.8	....	....	....	0.7	2.4	9.7	2.1	16.7	17.3	49.9	....	....	....
3 Abbé: 4′×18′–31 R. P. M.	Feed	"	60.6	....	....	0.3	5.3	6.4	13.3	2.8	20.5	19.0	32.0	....	....	....
	Discharge	"	60.8	....	....	....	0.6	2.1	8.3	2.0	16.0	16.6	52.5	....	....	....
4 D. E. W. Co.: 5′×20′–26½ R. P. M.	Feed	"	58.9	....	....	0.3	5.2	6.2	14.4	2.5	18.5	20.0	32.5	....	....	....
	Discharge	"	62.7	....	....	....	0.2	0.9	5.6	2.2	10.9	14.3	64.6	....	....	....
1 El Oro Liner	Feed	3/27	56.7	65.9	50.4	0.2	5.0	7.5	19.0	4.0	20.8	19.8	23.5	....	....	....
	Discharge	"	56.9	....	....	....	0.2	2.0	10.5	3.0	16.0	15.2	52.2	18.8	32.8	0.58
2 Silex Liner	Feed	"	64.8	100.0	54.4	0.2	5.5	7.5	18.8	5.0	20.0	18.0	25.0	....	....	....
	Discharge	"	65.9	....	....	....	1.0	4.2	15.5	3.0	18.0	17.8	39.5	14.5	27.0	0.54
3 *a*Silex Liner	Feed	"	64.9	70.3	37.0	0.2	4.4	7.4	18.2	4.5	21.6	16.8	26.6	....	....	....
	Discharge	"	65.0	....	....	....	1.0	3.2	14.0	4.0	18.0	14.5	44.5	12.6	27.0	0.47
4 *b*El Oro Liner	Feed	"	64.9	64.9	35.1	0.3	4.5	7.0	17.8	4.0	21.5	17.0	27.6	....	....	....
	Discharge	"	66.7	....	....	....	0.2	1.6	9.0	3.0	15.6	15.7	54.0	17.1	51.0	0.34
1	Feed	4/13	56.7	102.9	77.7	0.4	5.0	9.8	21.0	4.5	20.0	18.7	20.5	....	....	....
	Discharge	"	58.9	....	....	....	0.8	4.0	14.0	4.3	18.5	15.5	42.7	22.8	....	0.70
2 *c*	Feed	"	62.8	115.5	68.3	0.4	4.8	10.0	21.2	4.2	21.3	19.0	19.0	....	....	....
	Discharge	"	63.4	....	....	....	1.8	5.5	17.0	4.4	21.0	18.5	31.7	14.7	....	0.55
3	Feed	"	62.7	113.6	67.6	0.3	4.9	9.9	21.0	4.5	20.5	19.0	19.1	....	....	....
	Discharge	"	63.0	....	....	....	1.5	4.5	16.5	4.4	20.0	18.0	34.0	16.9	....	0.62
4	Feed	"	62.4	103.8	62.6	0.4	5.0	9.9	21.1	4.4	20.5	18.9	19.7	....	....	....
	Discharge	"	63.4	....	....	....	0.7	3.8	13.5	4.2	18.4	15.2	44.0	25.2	....	0.50
1	Feed	5/20	52.1	46.0	42.0	1.2	12.0	11.0	18.5	3.8	16.8	12.8	23.0	....	....	....
	Discharge	"	52.8	....	....	....	0.2	1.5	8.2	2.0	14.8	13.8	58.0	16.1	....	0.49
1*d*	Feed	"	46.4	50.8	59.6	1.0	11.0	11.5	20.0	4.0	15.5	14.5	21.8	....	....	....
	Discharge	"	47.8	....	....	....	0.3	2.0	10.2	2.0	15.0	14.0	55.0	16.9	....	0.52
1	Feed	"	37.1	50.4	83.6	1.0	10.9	12.5	20.4	3.8	17.0	13.2	20.4	....	....	....
	Discharge	"	37.3	....	....	....	0.5	2.8	11.5	2.5	16.0	14.8	50.5	15.4	....	0.47
1	Feed	"	31.4	52.4	104.0	1.0	10.5	12.4	20.0	3.9	16.0	14.0	21.6	....	....	....
	Discharge	"	31.5	....	....	....	0.6	3.0	11.8	2.6	16.8	15.0	48.7	14.2	....	0.43
2	Feed	4/17	63.9	82.8	46.8	0.5	7.4	10.8	20.0	3.7	20.5	14.6	22.0	....	....	....
	Discharge	"	64.9	....	....	....	2.0	6.5	16.4	3.7	18.6	16.5	35.6	13.6	....	0.51
1 *e*	Feed	"	56.6	50.0	38.3	0.4	5.3	11.0	21.0	3.6	20.7	16.3	21.5	....	....	....
	Discharge	"	56.9	....	....	....	0.2	2.0	8.7	1.7	17.0	16.5	53.0	15.7	....	0.48
1 *f*	Feed	"	49.3	32.0	33.0	0.6	6.5	10.2	20.5	3.2	20.7	16.0	22.0	....	....	....
	Discharge	"	52.4	....	....	....	0.1	0.3	2.8	1.2	10.2	16.3	68.6	14.9	....	0.45
1	Feed	"	58.8	83.0	58.1	0.2	6.2	9.0	18.8	4.9	20.0	16.2	24.0	....	....	....
	Discharge	"	59.7	....	....	....	0.4	3.0	11.5	3.0	17.0	18.2	46.0	19.9	....	0.61
1	Feed	"	61.9	131.6	81.0	0.2	5.3	8.5	19.5	4.4	19.2	19.0	23.0	....	....	....
	Discharge	"	62.0	....	....	....	1.0	4.0	14.1	3.8	21.0	17.0	38.0	19.7	....	0.60
2	Feed	4/15	63.7	87.6	49.9	0.4	5.2	9.0	19.6	5.0	21.5	17.3	21.1	....	....	....
	Discharge	"	64.6	....	....	....	1.6	5.8	15.0	2.4	21.8	17.5	35.0	12.2	....	0.45
4	Feed	"	64.6	68.4	37.5	0.2	5.0	9.8	19.0	4.7	20.0	18.8	22.0	....	....	....
	Discharge	"	65.9	....	....	....	0.4	2.5	9.6	2.1	15.4	16.5	53.0	21.0	....	0.41
4 *g*	Feed	"	64.7	38.8	21.1	0.2	5.2	9.9	20.7	3.0	22.2	17.0	21.5	....	....	....
	Discharge	"	65.2	....	....	....	0.2	1.2	7.8	1.5	15.0	14.5	59.5	14.7	....	0.29
4	Feed	"	64.9	110.8	59.9	0.3	4.5	7.5	18.2	4.5	20.5	17.5	26.8	....	....	....
	Discharge	"	65.5	....	....	....	0.6	2.8	12.0	2.0	20.8	16.1	45.2	20.4	....	0.40
4	Feed	"	65.3	128.4	68.2	0.2	4.5	8.0	18.7	3.9	22.0	16.2	26.4	....	....	....
	Discharge	"	66.5	....	....	....	0.6	3.1	3.2	3.4	20.0	17.2	42.0	20.0	....	0.39
1 *h*	Feed	9/16	60.5	141.0	92.0	0.4	10.5	15.0	22.0	4.5	20.0	15.0	12.6	....	....	....
	Discharge	"	61.1	....	....	....	6.0	11.0	19.0	6.2	18.0	15.5	24.3	10.8	....	0.33
2	Feed	"	67.9	127.0	60.0	0.3	9.3	15.8	25.4	4.0	18.8	13.2	13.2	....	....	....
	Discharge	"	67.6	....	....	....	8.0	12.5	20.9	5.0	19.2	12.5	21.9	11.0	....	0.41
3	Feed	"	67.1	128.4	63.0	0.5	12.0	14.0	21.5	5.0	20.2	14.4	12.4	....	....	....
	Discharge	"	67.3	....	....	....	7.5	12.6	21.8	4.0	18.5	14.0	21.6	11.8	....	0.44
4	Feed	"	67.0	130.0	64.0	0.4	10.2	14.5	24.8	4.0	20.8	12.8	12.5	....	....	....
	Discharge	"	68.2	....	....	....	5.0	11.5	19.3	2.6	20.0	11.5	30.1	22.8	....	0.45
4	Feed	9/21	61.3	130.0	82.0	0.5	10.5	17.0	22.0	5.2	18.0	14.0	12.8	....	....	....
	Discharge	"	....	....	....	....	6.0	12.0	21.0	5.0	17.5	13.2	25.3	16.2	....	0.32
4 *i*	Feed	"	56.1	140.8	110.0	0.5	10.0	16.0	22.5	5.0	19.0	15.5	11.5	....	....	....
	Discharge	"	....	....	....	....	6.5	13.0	18.3	5.1	18.0	14.2	24.9	17.9	....	0.35
4	Feed	"	50.6	162.0	160.0	0.7	12.0	17.1	22.0	5.0	20.0	13.0	10.2	....	....	....
	Discharge	"	....	....	....	....	7.0	11.0	21.0	5.5	19.4	13.1	23.0	20.8	....	0.41
4	Feed	"	66.3	157.2	80.0	0.6	11.6	16.2	23.2	4.4	20.8	12.0	11.8	....	....	....
	Discharge	"	....	....	....	....	6.5	11.9	20.0	4.2	17.2	13.5	26.7	23.4	....	0.46
4 *j*	Feed	9/25	67.1	79.0	41.0	1.0	13.5	15.3	19.1	5.0	20.5	12.0	13.6	....	....	....
	Discharge	"	68.1	....	....	....	5.0	10.6	17.0	4.0	16.5	13.2	33.7	15.9	....	0.31
4	Feed	"	58.1	98.0	73.6	1.2	12.0	16.5	20.0	5.1	20.0	13.0	12.2	....	....	....
	Discharge	"	58.9	....	....	....	5.3	11.0	18.2	4.0	17.3	13.0	31.2	18.6	....	0.365
4	Feed	"	52.8	110.4	95.0	1.0	13.0	15.5	20.5	4.9	19.4	13.9	12.7	....	....	....
	Discharge	"	53.5	....	....	....	5.5	11.2	17.5	5.0	18.0	12.8	30.0	19.1	....	0.375

a Fed at less than capacity to determine the efficiency of mill. *b* Same as *a*. *c* Same as *a*. *d* Fed at less than capacity to determine effect of per cent. of solids in feed. *e* Fed at less than capacity to determine effect of various feeds. *f* Same as *e*. *g* Fed at less than capacity for same purpose as *e*. *h* Determinations of feed per minute vitiated by power troubles during test. *i* Power troubles during test. *j* Determination of feed not correct-power-troubles.

fact that they are 3 ft. shorter, which reduces the capacity somewhat, and they have a greater diameter, which tends toward a reduction of their horse-power efficiency.

This statement as to horse-power efficiency is not absolutely proven by the above tests, but in every case the efficiency has been lower in mills of greater diameter, except one in which the small mill did not have more than about 60 per cent of its most economical feed.

The 5-ft. x 20-ft. mill (which is mechanically the best built one) has shown in every comparative test a lower grinding efficiency than the smaller mills, but it would not be fair to look upon this deduction as final, owing to reasonable doubt as to the accuracy of determination of quantities.

Screen Tests on Waddell Chilean Mills.

These tests, shown in Table III, were made to determine the best feed for these mills, and it requires but a superficial examination to decide that the heaviest feed which can be taken care of by the discharge screen in use is the most economical one. In fact, based on the results of these tests, the entire launder system for distributing the feed for these mills is being replaced by a "distributing tub" system designed to do away with the inequalities of the launder system and to permit every mill to receive at all times as near as possible its maximum feed.

The mill efficiency in the above tests was computed in kilos per minute, ground to pass a 200-mesh wire screen, not as a definite standard, but as a convenient means of comparison for the different mills.

A Reichsgericht Decision on the Scope of the Patent Treaty Between the United States and Germany.

In our correspondence columns in this issue "Manufacturer" refers to a recent Reichsgericht decision of considerable importance with respect to the patent treaty between this country and Germany. The Reichsgericht is the German Supreme Court, and the decision in question was rendered in the patent litigation of the National Cash Register Company, of Berlin, defendants, now the National Cash Register Company, of Dayton, Ohio, appellants, against Schubert and Salzer, complainants and appellees, regarding withdrawing the German patents 119,260, and 119,155.

These patents, which refer to improvements in cash registers, were taken out in the name of the National Cash Register Company, a limited company, the place of business of which was Berlin.

On July 16, 1907, the complainant (Schubert and Salzer) moved that the patents should be withdrawn according to § 11, No. 1, of the German patent law, because at that time (more than three years after the publication of the granting of the patents) the inventions were not worked in Germany to a sufficient extent. All the essential parts of the cash registers protected by the patents were manufactured by the American parent company, the National Cash Register Company, of Dayton, Ohio, and were imported to Germany from this country.

The German Patent Office, in a decision of May 11, 1908, ordered the withdrawal of the patents according to the motion of the complainants, Schubert and Salzer.

Against this decision of the German Patent Office the National Cash Register Company, of Berlin, appealed. After the papers had been submitted to the Reichsgericht and after a date for the oral hearing had been arranged, the name of the firm owning the patents underwent a change. The firm name is now the National Cash Register Company, Ltd. This change was registered in the Patent Office and in the papers in this suit. Further, all four patents were assigned on May 25, 1909, by the National Cash Register Company, Ltd., in Berlin, to the National Cash Register Company, of Dayton, Ohio, which is the American parent company of the Berlin firm. Accordingly the ownership of the patents was also changed in the registers of the Patent Office to this American firm, and the assignment of these patents was published in the *German Imperial Gazette* of July 29, 1909.

Further, on Aug. 1, 1909, in No. 47 of the *Imperial Gazette*, the patent treaty between the German Empire and the United States concerning mutual industrial protection, which took effect on Feb. 23, 1909, was published.

The oral arguments of the attorneys, in accordance with the direction of the Reichsgericht, were restricted to the question whether this patent treaty should influence the decision in the suit concerning these two patents, and, if so, what kind of an influence the patent treaty should exercise.

The German Reichsgericht, in its decision rendered on Nov. 21, 1909, reversed the decision of the German Patent Office and denied the motion to withdraw patents 119,155 and 119,260.

In the decision of the Reichsgericht the question is first discussed whether the American firm should be admitted as the principal party in this suit for the reason that the American firm is now registered as owners of the patents in the Patent Office; or whether, in view of the opposition of the complainant, this should not be done. The Reichsgericht decided on the basis of a lengthy argument on the applicability of certain paragraphs in the German patent law and the German civil law that "the opposition of the complainant against the admission of the American company as defendant in this suit is to be disregarded, and it is decided that this latter firm is the main party entitled to defend the patents."

"As far as the subject-matter itself is concerned, the withdrawal of the patents, even after it had been justly decided by the Patent Office, based on § 11 of the patent law, cannot be affirmed by the court, after the treaty between the German Empire and the United States of America referring to the mutual industrial protection, dated Feb. 23, 1909, has taken effect on Aug. 1, 1909, and after the patents have been assigned to the present owner.

"The treaty which has been passed by the Federal Council and by the Diet, and which has been published in the *Imperial Gazette*, is legally binding. It is provided in article 1, sentence 1, that those laws of the one country of the high contracting parties which decree the withdrawal or other restrictions in case of non-working of a patent or other protective rights, should apply to patents belong to citizens of the other high contracting party, only as far as patents belonging to citizens of this country are affected by their own laws. The effect of this provision for the patents which are here under discussion becomes evident from the circumstance that according to § 11 of the German patent law the owner of the patent is obliged to work his invention to an adequate extent, if he does not want to lose his patent rights, but that, on the other hand, there is no working clause in the United States. As appears also from the memorandum with which the Imperial Chancellor submitted the treaty to the Diet, this treaty sets forth that American citizens are freed from the provisions of the German law regarding the working clause. As it is there further stated, 'they are hereby placed on an equality with the German citizens who obtain patent protection in the United States without any obligation to work their patents,' therefore the treaty provides that the working clause which is decreed by the German law does not apply to patents belonging to a citizen of the United States. Because in his home country the working clause does not exist, he is not subjected to the German provisions for a working clause on account of his nationality.

"The question whether the provisions of this treaty should affect this suit which has been started before the ratification of the treaty will be discussed later on. If we at present disregard this point, it would follow that for the reason that the patents in question now belong to the American firm, the motion for the withdrawal of the patents would not succeed. The complainant opposes this and asks for a different interpretation of the treaty from two points of view.

"First, the complainant contends that the treaty only speaks of patents which have been 'granted' to citizens of the other country. This means to the applicant for the patent or to that person to whom the patent has originally been granted, but it seems to exclude later assignees, such as the present complainant. This point is not well taken. It is contradicted by the English text, which is also published in the *Imperial Gazette*. This reads: 'Patents enjoyed by the citizens of the other contracting party.' That means patents the ownership of which is enjoyed by the citizens who possess them. * * *

"The complainant has further argued that in the treaty the expression 'citizens' has been used and that citizenship is a quality which is inherent only to physical individuals and since the present defendant is a corporation doing business in the State of Ohio under the American law, it cannot be a 'citizen.' But this argument must also necessarily fail. The point whether the terms 'citizens,' 'subjects,' used in treaties apply to physical persons only has been already adjudicated and denied by the Imperial Court. * * * It must be decided that any corporation or company doing business within the territory of any two countries and incorporated under the laws of the country must be considered 'citizens' within the meaning of the treaty.

"A third restriction of the treaty, which, however, has not been argued by the complainant, has been mentioned in a publication of the *Zeitschrift für Industrierecht* (1909, page 229). It is there contended that an American is only freed from the working of his German patent if he owns at the same time a corresponding home patent. The testimony in this suit differs as to the question whether such is the case with the patents in litigation, so that further testimony would have to be taken if this point were argued. But the point is not well taken. * * *

"Finally, the question must be considered whether the provisions of the treaty should apply in a suit which has been brought before the treaty took effect, and in which suit the courts of the first instance has already rendered an unfavorable decision. In this respect it must at once be denied that new laws enacted in favor of the citizens of the United States are only effective for patents which are applied for or granted after the treaty took effect. Neither the context nor the purpose of the treaty allows such a restricting interpretation. Evidently the purpose of the treaty was to make the freedom from the working clause unrestricted, at least from now on, and to enforce this freedom also in case of older protective rights. It is only debatable how the treaty affects patents which have existed beyond the limit defined in § 11 of the patent law and which, within these limits, have not been worked, so that according to the present law a motion for their withdrawal would be allowed, as has been the case with the patents here in suit.

"In answering this question, the general principle must be considered that new laws must not affect well-acquired private rights. This would apply, if complainant after the lapse of three years, during which the patent had not been worked, would have acquired a private right regarding the withdrawal of the patent. But this is not so. A private right for the withdrawal of a patent does not exist. The withdrawal possesses the nature of a popular complaint which the individual only exercises for the benefit of the general and public interest. A patent 'may' in case of certain legal presumptions be withdrawn, but it must not be done necessarily. The court possessing jurisdiction may not insist on withdrawing, if considering the individual case it concludes that the public interest of the home country is not injured or if it decides that the owner of the patent alleges good reasons for non-working. A decision lies within the free judicial discretion and it must be rendered strictly in accordance with the facts prevailing at the time of rendering the decision. Especially for the higher instances of the court, the circumstances prevailing at the time when the decision is rendered, are binding.

"The question what is to be considered as public interest might be differently answered. It may be held of primary importance that the patent law should serve the national industry and that it must help to increase domestic welfare by increased opportunity for labor; or it may be held that the free international exchange of all technical progress and the new products which are obtained in this way may be the first consideration. In this regard the courts must judge in accordance with the existing laws. The patent law in § 11 sanctions the protection of the national industry. Nobody must be permitted to utilize a patent to the exclusion of others. The inventor must within a certain time work the invention at home. The Paris International Convention for the Protection of Industrial Property and the Brussels additional treaty confirmed this principle. The treaty with the United States, however, supports the second point of view. By granting to the American industry which by their domestic laws is freed from the working clause certain privileges in Germany which the national industry does not enjoy and permitting the American to utilize his German patents to the exclusion of the German industry, the treaty brings out other and new viewpoints for the definition of the public interest in relation to the industry of this country. After the treaty came ino force and during its duration, the German courts cannot enforce any more upon a citizen of the United States the protection of the German national industry as a public interest.

"For these reasons the motion to withdraw the two patents in suit must be denied."

This decision of the German Reichsgericht is a model of impartiality. The definition of the scope of "public interest" in the concluding part of the decision shows a spirit of enlightened self-interest and broad-mindedness which is admirable.

Notes on Chemistry and Metallurgy in Great Britain.

(From our Special Correspondent.)

The Institute of Metals.

The annual general meeting was held on Jan. 18 and 19, at the Institution of Mechanical Engineers, when the new president, Sir Gerard Muntz, delivered his inaugural address, in the course of which he said that the absence of a general knowledge of the non-ferrous metals was simply appalling; and a large field existed for young metallurgists in such metals. There was probably a larger extent of investigation before the Institute than was open to any kindred association.

In opening the discussion on the paper on **"The Properties and Constitution of the Copper-Arsenic Alloys,"** by Mr. J. D. Bengough and Mr. B. P. Hill (abstracted on page 95 of our February issue), Professor Huntington said he had a notion he had done some work on the subject some years ago. The first point attracting his attention was the statement that arsenic gave copper good working properties at high temperatures. His experience was that arsenic had a very bad effect on copper at high temperatures.

Mr. W. Rosenhain, with reference to the formation of cracks, said Professor Huntington's theory appealed to him rather than the authors' deduction. Raising the specified limit of arsenic could not be recommended without further research; and it would be essential to learn something more about fatigue and resistance to shock.

Mr. Rhead said that two or three years ago he was working on alloys of electro-copper containing from 0.5 to 1.5 per cent of arsenic. With 0.5 per cent distinct separation of arsenic compounds, on the borders of the crystals, took place. A similar segregation occurred when antimony was used. On two occasions he had had evidence of serious pollution of arsenic alloys by gases containing chlorine. At their first Birmingham meeting he had pointed out the serious effects produced by heating copper for long periods in reducing gases. The production of oxide accounted for the cracked appearances.

Mr. Bengough replied, as to the reaction between the oxide

and reducing gases, that there was a critical temperature at which the reaction took place. It did not occur below 600° C. He proposed to make his general reply in a written communication.

Mr. Ernest A. Smith's paper on **"The Assay of Industrial Gold Alloys"** followed. It was abstracted on page 92 of our last issue.

Professor Gowland attached a high value to this paper by reason of its containing much original matter hitherto unpublished. Mr. Smith was especially fitted for writing such a paper. The old Japanese 9-carat alloy contained gold and silver only, and the silver could be removed from the surface by pickling. The Japanese alloy now contains silver and copper. There was difficulty in taking a fair sample from a gold-silver-copper alloy; in fact, a dip sample was necessary. When silver only was alloyed with the gold the old touchstone test gave reliable indications for the assay.

Professor Turner concurred as to the great value of the paper, but regretted that any reference to cadmium in the alloys had been omitted.

The next paper read was by Dr. R. Seligman and Mr. F. J. Willott on **"The Analysis of Aluminium and its Alloys,"** in which the authors strongly urged the desirability of standardization of methods, and fully described the procedure they had found consistently reliable. (An abstract of the paper appeared on page 94 of our last issue.) The discussion was adjourned.

On the second day, Jan. 19, the first paper taken was on **"A Contribution to the Study of Phosphor Bronze,"** by Mr. O. F. Hudson and Mr. E. F. Law, who said that the object of their research was to investigate the relation between the constitution of the phosphor-bronze alloys and their mechanical properties. (See the abstract on page 95 of our last issue.)

Mr. A. Philip fully recognized the great value of the work carried out by the authors, but thought that the evidence they had produced of the existence of a triple alloy of copper, phosphorus, and tin, was not quite conclusive.

Dr. Rosenhain was also of opinion that the evidence adduced by the authors did not adequately support their conclusions. When the additional facts embodied in the full details of their work were placed before the Institute the authors would have made a most valuable contribution to the subject which would be of permanent interest.

Mr. Spence Thomas regarded the matter from the point of view of a user of phosphor-bronze. In his experience the life of bearings in hot mills, under exactly similar conditions, varied from 1 month to 15 months. He urged co-operation between producers and users in the hope of securing greater durability.

Professor Turner remarked that the differences in mechanical properties between the various grades of phosphor-bronze were as great as those between cast iron, wrought iron and steel. Whatever opinions might be entertained as to the existence of the triple alloy described in the paper, the fact remained that there was some constituent of phosphor bronze which disappeared and reappeared under varying conditions of heat treatment, and this fact was most important in connection with the subject.

Mr. Law replied that the matters referred to by Mr. Spence Thomas might be explained by the low melting point of the triple eutectic, viz., 620° C., the consequence being that bearings in which it occurred were not able to withstand the high temperature encountered in hot mills.

Mr. Spence Thomas said that when such bearings were used in cold mills their life also varied, and had been found both longer and shorter than in hot mills.

Mr. Gaywood attributed the trouble with the bearings to an excess of lead in the phosphor-bronze.

Mr. Law had arranged to illustrate the paper by lantern projections from colored photomicrographs on Lumière plates; but, unfortunately, the impracticability of securing sufficient exclusion of daylight, or a suitable disposition of the apparatus, did not permit of the desired degree of distinctness being attained.

Mr. T. Vaughan Hughes read a paper on **"Failure in Practice of Non-ferrous Metals and Alloys,** with Particular Reference to Brass Loco-Tubes." (Abstracted on page 94 of our last issue.)

Dr. Rosenhain, in the discussion, said he found difficulty in acquiescing in the view that a film of non-conducting substance one-tenth of a millimeter in thickness could so prevent the transmission of heat as to raise the temperature to 800° C. Had the author further examined the tubes from which the deposit had been scraped? If the theory were true, the effect of over-heating would be found at the firebox ends of nearly all the tubes, and such evidence, if forthcoming, would be almost conclusive. He did not concede that there was justification for assuming that overheating occurred only after the tubes came from the makers.

Professor Turner said the thinning of the tubes might be attributed to various causes. Abrasion by particles of clinker was one; and for another there might be chlorine in the gases. Examination of the films on the surfaces of tubes undergoing corrosion would show the presence of a considerable quantity of chlorine. If lead were present it certainly caused failure; but corrosion was known to occur in tubes which were commercially pure. Tubes were cold-drawn, the ends were expanded afterwards, and the damage was often caused by the final annealing.

Professor Huntington agreed that the annealing was probably responsible for troubles. The usual difficulty was in getting a continuous history of the material from its manufacture to its use.

Mr. Heathcote remarked that, from a paper recently read before the Society of Chemical Industry, it appeared that oil in the feed-water had caused the tubes to attain a temperature so high that globules of molten copper were found on their fire-sides. This represented 1000° C.

Mr. Bengough said that overheating, doubtless, occurred during the expanding. The strength of the material was not very much affected at ordinary temperatures; but under stress at high temperatures it was seriously deteriorated. He considered that prolonged heating at a moderate temperature would produce the same structure as heating for a short period at 800° C.

The president observed that he had experienced corrosion from the outside of the tubes; he had known tubes to have been corroded quite through where alkaline water was used. The Midland Railway had had much difficulty in that respect. As to the effect of chlorine, the old tubes returned had chlorides as well as sulphides in the tube.

Mr. Vaughan Hughes explained that the fuel used was coke. No chlorides of copper or zinc were found, but sulphate and chloride of calcium.

Institution of Mechanical Engineers.

Alloys Research Committee.

Mr. E. B. Ellington presided at a meeting of this Institution on Jan. 21, when the ninth report of the Alloys Research Committee was presented. It deals with the properties of various alloys of copper, aluminium and manganese, and corrosion of copper-aluminium alloys by sea-water.

Sir W. H. White, chairman of the committee, said the work of that committee was to so conduct the research that the chief results would be of practical utility to mechanical engineers. Some of the earlier reports had, he thought, been unjustly criticized in that respect. The results of the work done were so stated as to be capable of being applied commercially in the manufacture of non-ferrous metals.

Sir Gerard Muntz stated that his practical experience enabled him to confirm some of the results arrived at in the report. His firm was making aluminium castings for motor cars, and

great difficulty had been encountered in the heat treatment. The cutting qualities of some of the alloys had considerable interest for him; and that was a point which, among others, he should try to follow up as a manufacturer.

Prof. J. O. Arnold remarked that the work which had been done was in a direction new to engineers.

It appeared that from a mechanical point of view they must not expect too much from micrographical analysis. Molecular changes, both in ferrous and non-ferrous metals, demanded investigation in the interests of public safety. Such changes were often not detected by the usual tests, but had a serious effect on the properties of metals.

The discussion stands adjourned to Feb. 18.

Market Prices.

Copper.—Starting at close on £62 per ton, the price of standard fluctuated frequently, though not to great extent, up to Jan. 12, it then commenced to fall, but picking up slightly on the 18th, recovered ultimately to £60 17 6.

Tin.—Dropped smartly from the opening price of £153 to £148 10 0 during the first three days; then recovered to £151 7 0, after which fairly steady fall to £147 10 0.

English Lead.—Flat throughout the month at £14 to £14 3 0, closing £13 7 6.

Iron, Cleveland Warrants.—Rose fairly steadily from 51/- to 52/3.

Scotch Pig.—Followed much the same course as Cleveland, i.e., during the month (6th to 13th and 20th) carrying the price from 62/6 to 65/-; closing at 67/-, but little doing at this price.

Aluminium ingots, in ton weights	£75	0	0
Antimony, black sulphide powder, per ton	20	0	0
Sulphate of ammonia, f.o.b. Liverpool, per ton	11	12	6
Copper sulphate, per ton	19	15	0
Caustic soda, white, 77 per cent, per ton	11	2	6
Bleaching powder, 35 per cent, per ton	4	5	0
Shellac, standard T. N., orange spots, cwt	3	8	6
Carbolic acid, liquid, 97 to 99 per cent, gal			11
Creosote, ordinary good liquid, gal			2⅜
Naphtha solvent 90 per cent at 160° C., gal		1	3½
Rubber, Para, fine, lb		7	8
Platinum, per ounce troy, nominal	5	15	0
Zinc (Vicille Montague bud), per ton	27	10	0

London, England.

Recent Metallurgical and Chemical Patents

Iron and Steel.

Basic Open-Hearth Process.—Mr. Louis M. Atha, of Newark, N. J., remarks that the ordinary basic open-hearth process of making steel from a mixture of pig iron, steel and iron scrap is expensive in certain localities owing to the high price of pig and the large amount of limestone necessary to add to the charge. The pig iron or cast iron are employed for the carbon they contain, to melt down the steel. Steel scrap could be substituted if carbon was introduced in some form separately. Mr. Atha states that while pulverized coke, charcoal or anthracite will not do, because they are carried off with the vapors, oil retort carbon may be advantageously employed. He uses 75 per cent steel scrap, 18 cast iron or pig iron, 2 carbon, and 5 limestone. "These proportions give a saving of about 30 per cent of pig and 50 per cent of limestone. By using steel scrap, which is low in phosphorus, it is not necessary to use as large a quantity of limestone as usual." (943,171, Dec. 14, 1909.)

Tool Steel.—Mr. John W. Evans, of Belleville, Ont., Can., patents, a tool steel, containing 92 per cent or more of iron, 3 per cent or less of titanium, 2 per cent or less of vanadium, 3 per cent of nickel or less, and 1 per cent or less of carbon. It has "the characteristics of being tough and hard to the end that it will retain an edge when working hard metals at high speed." (948,166, Feb. 1, 1910.)

Furnace Construction.—Details of construction of a special furnace for the heating of the ends of blanks from which bolts are to be manufactured are described in a patent of Mr. Edwin Alls. (943,763, Dec. 21, 1909; assigned to Monarch Engineering and Mfg. Co.)

Electric Steel.—Three new modifications of induction furnace designs for steel refining, due to Grönwall, Lindblad, and Stalhane, Unger and Grunwald are described below under Electrical Furnaces. At the same place will be found a method of Queneau of using the pinch effect for mixing an electric furnace charge, and a method of Strauss of making calcium silicide for steel refining.

Copper.

Fractional Roasting and Flotation Process.—To separate the valuable metals from such ores as chalcopyrite $CuFeS_2$, bornite or crubescite Cu_3FeS_3 and mixtures of the same with pyrites in which copper is chemically combined with iron, Mr. A. S. Ramage, of Newark, N. J., subjects them to a fractional roasting process, with subsequent separation by flotation. For instance, in case of an ore containing iron pyrites and chalcopyrite, with a content of about 5 per cent of copper and from 30 to 40 per cent of sulphur, the ore is roasted at about a red heat in a furnace capable of utilizing the exothermic reaction between the ingredients of the ore. The roasting is conducted at a temperature sufficient to decompose only the iron sulphide, and leave the copper in the form of copper sulphide. The roasted ore is then crushed to at least fifteen mesh and passed through a solution of acid sulphate of soda and free nitric acid (the solution being formed by adding nitric acid to sulphate of soda), which solution is kept near the boiling point. The copper sulphide immediately rises to the top of the bath and can be floated off. Any copper oxide which may have been formed in the roasting operation, at once dissolves and can be recovered from the solution by any of the well-known ways.

Where the ore contains besides iron pyrites and chalcopyrite, zinc blende in quantity, the ore is roasted at a temperature of not over 600° C, with the result that the iron sulphide only is decomposed. The roasted ore is then subjected to the acid sulphate of soda solution in the manner before described, the solution being kept at nearly the boiling point, when the unchanged sulphide of zinc and copper rise to the top of the bath and are floated off, thus being together separated from the iron oxide. The copper and zinc sulphides are then roasted at about 700° C, until all the zinc sulphide is decomposed, the burnt mixture, after cooling, being treated with dilute sulphuric acid, whereby the zinc is completely dissolved, and the copper sulphide is left unchanged. The zinc may then be recovered from the solution by electrolysis in any preferred manner.

In the case of the ores of the Cobalt district, Dominion of Canada, which are principally cobalite, nicolite, and mixtures of chalcopyrite and pyrites containing silver in the metallic state and also as sulphide and sulpharsenide, these minerals are "floated" from the gangue, the metallic silver remaining with it, and from which it is mechanically separated. The sulphides and sulpharsenides of cobalt, nickel, iron and copper are then roasted at about 800° C, the roasted ore is "floated" as above and the copper sulphide floated off. The iron, nickel, and cobalt are reduced together as an alloy, electrolytically. (949,002, Feb. 15, 1910; assigned to Chemical Development Co.)

Reduction of Copper Sulphide.—The nearly pure sulphide

of copper obtained in the above process is placed by Mr. RAMAGE in a cylindrical furnace, where it is reduced to the metallic state by mixture of hydrogen and water gas at a low red heat. At this temperature the hydrogen reduces the copper sulphide to metallic copper in the form of a powder, while the carbonic oxide and sulphuretted hydrogen gases pass off and are led under and around the cylindrical furnace and burned to supply the heat necessary for reduction. The reduced metallic powder is delivered from the furnace into air-tight chambers and allowed to cool. The ore could be reduced by means of carbon, but some undecomposed carbon always remains, and in the subsequent electrolysis contaminates the electrolytic copper, so that the gaseous reduction is preferable. The cold metallic powder is preferably then used as an anode in a suitable electrolyte. The cathodes can be sheets of copper or revolving tubes. (949,003, Feb. 15, 1910.)

Wet Process for Pyritic Copper and Copper-Nickel Ores.—Mr. J. T. CARRICK, of Johannesburgh, Transvaal, digests the hot desulphurized crushed ore with an excess of hydrochloric acid, in the absence of oxygen, until the iron and also the nickel are dissolved out. (By treatment of the digester liquor with ammonia and aspiration of air through it, the iron is precipitated, and after removal of the iron precipitate, the nickel is thrown down by the addition of lime.) The ore remaining in the treatment vat after removal of the iron and nickel consists of a porous mass of gangue and sulphuric acid and by injection of compressed air the sulphide is oxidized to cupric sulphate, which is leached out in about 24 hours. (947,789, Feb. 1.)

Separation of Copper from Other Metals.—See below the abstracts of the patent of Chalas on copper-nickel separation under Electrolytic Processes and of the patent of Chance on treating copper-iron matte under Electrolytic Furnaces.

Gold and Silver.

Agitating Ore Pulp.—In the treatment of ore pulp there is a difficulty in preventing the heavier particles from settling to the bottom of the tank, where they would be practically withdrawn from the effective action of the cyanide solution. To prevent this, Mr. BERNARD MACDONALD, of Guanajuato, Mexico, employs the apparatus shown in Fig. 1, which makes use principally of compressed air, without the employment of mechanical stirrers and agitators. The charge is supplied to the tank from the overhead main *a* into the funnel *d* at the top of the charge pipe *e'*. The funnel *d* has a perforated bottom *d'* upon which rests the cyanide to be brought into solution. At its lower end the tank is subdivided into several compartments by transverse partitioning with inclined sides. In the illustration (in which the lower diagram is a horizontal section along the line 2-2 of the upper diagram), this partitioning is in form of a single ridge-like gable *i*, so that in this case there are only two compartments. In this case the charge pipe *e'* rests upon the summit of the gable *i*, and at one end thereof, and from this point it extends downwards and forwards, terminating in branch jets *h* directed toward the valve casings *j*. The charge pipe *e'* has a height of 40 to 47 feet, so that the hydrostatic pressure is strong enough to insure a vigorous exit of the charge from the jet openings. After the charge of ore pulp or slime has been supplied to the tank, or at intervals during such supply, the valve *f* at the top of the charge pipe is closed so as to cut off further supply of pulp, and through the pipe *g* (right below this valve) compressed air is admitted into the charge pipe *e'* to agitate the charge and prevent settling. Air-injector jets extend upwardly through the bottom of the tank into the valve casings *j*; they are connected with the supply of compressed air through the piping *p*. Right above the valve casings *j* are provided vertical transfer pipes *k*. By the action of the compressed air the heavy particles of pulp which tend to settle down in the pockets at the bottom, are driven up into the transfer pipes *k*, and are discharged again into the tank at the top through the T-connections *o*. In this way the whole pulp is continually stirred up and is being kept in a practically homogeneous consistency. After the treatment is completed, the pulp is discharged through the down-takes *g'* and pipe *g* at the bottom to the filter press. (948,766, Feb. 8, 1910.)

Electrolytic Amalgamation.—See the abstract of the patent of Alling below, under Electrolytic Processes.

Zinc.

Reduction by Carbon Monoxide.—A process for reducing zinc oxide to metallic zinc by carbon monoxide, practically pure and free from nitrogen, is patented by Mr. OSCAR LOISEAU, of Selaigneaux, Belgium. The carbon monoxide gas is produced at a temperature somewhat above the reduction

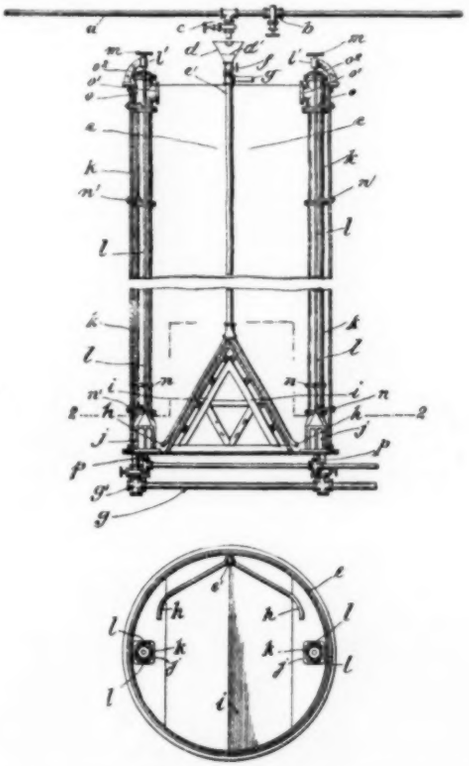


FIG. 1.—AGITATION OF PULP IN CYANIDE TANK.

temperature of zinc oxide (1400° C). The simplest way to produce the carbon monoxide gas is to have an incandescent mixture of coke and zinc oxide in a large closed reduction chamber and to blow pure oxygen, mixed with pure carbonic acid (free from nitrogen), over this mixture. The less the proportion of carbonic oxide compared with the oxygen, the higher is the temperature of the carbon monoxide gas produced. The reduction of the ore occurs according to the usual reactions; the role of the reducing carbon in the mixture is to transform immediately into carbon monoxide the carbonic acid derived from the reduction of the ore. The metallic zinc is obtained in separate condensers. The chief advantage of such a process would be the employment of a large-unit reduction chamber instead of the many retorts in present zinc smelting practice. The method is especially interesting as another indication of the great interest now being taken by various metallurgists in Belgium in the use of liquid air for the separation of oxygen and nitrogen, and the uses of pure oxygen for various metallurgical purposes. (947,831, Feb. 1, 1910.)

Electric Zinc Smelting.—A note in the abstract of a patent of Queneau on using the pinch effect for agitating an electric furnace charge, found below under Electric Furnace, refers to electric zinc smelting.

Various Metallurgical Patents.

Combined Roasting and Smelting Furnace.—Much has been heard last year of the Fink furnace, on account of the trial which it has undergone at Garfield, Utah, as described in

our Vol. 7, page 287. A patent of the inventor, Dr. Edward Fink, of Milwaukee, Wis., describes the furnace as follows: It is a combination of a heating or roasting barrel *a* and a smelting barrel *b*, which are arranged one above the other. Both barrels are charged with pulverized ore and fluxes and are rotated, the openings *i* of the barrel *a* and the tap holes 3 and 5 of the barrel *b* being closed. Fuel and air are supplied to the burner nozzles *q*, while air is blown through the pipe *s* so as to direct the hot blast over the ore in the smelting barrel *b*. By the rotation of the two barrels, the ore and the fluxes are thoroughly mixed and under the action of the hot blast in the lower barrel *b* the ore in it gradually begins to melt; the gaseous products of combustion escape through the flue *f* into the barrel *a*, where they heat the ore contained in it and finally escape through the flue *g*. The ore in the barrel *a* is thus gradually heated, and if it contains considerable sulphur this is ignited and the ore begins to roast; air being supplied thereto if necessary through the connection 6. The air blown through the tube *s* is heated so that a true hot blast is issued from nozzle *q*. When the smelting operation in barrel *b* is concluded the slag and the molten metal are withdrawn and by means of the connection *o* and the screw conveyor *n* the roasted ore from the barrel *a* is now brought into the melting barrel *b*. Then the conveyor is again removed from the hole *m* and the latter is closed. Fresh ore is filled into *a* and the operation starts again. For converting or refining operations, as, for example, for converting matte produced from copper ores containing considerable sulphur into an enriched matte or blister copper, one or more twyers *w* are introduced into the barrel *b* and are connected with the blast pipe *z* of the blower 2. Each twyer is adjusted so that its inner end will project slightly below the surface of the molten

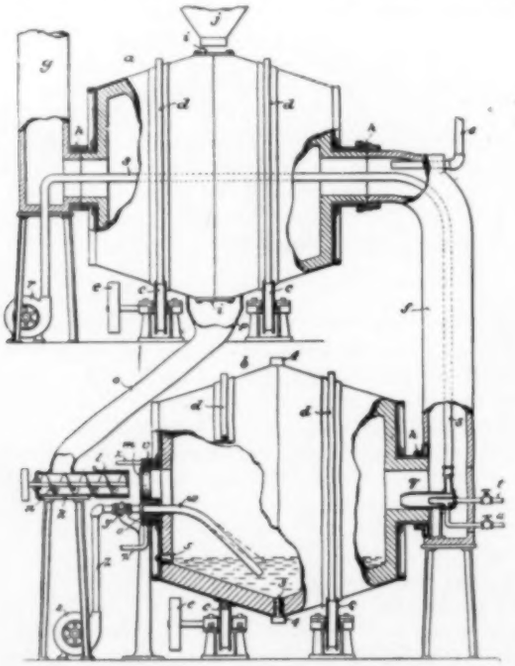


FIG. 2.—COMBINED ROASTING AND SMELTING FURNACE.

matte. Air is then blown and the barrel is rotated and a strong oxidizing flame is projected from the nozzle *q* over the matte. (948,468, Feb. 8, 1910.)

Nickel-Cobalt-Silver-Arsenic Ores.—For the smelting of ores which contain, besides silver, considerable quantities of nickel, cobalt, and especially arsenic (for instance, 300 to 10,000 ounces of silver per ton, 10 to 30 per cent nickel and cobalt, 5 to 40 per cent arsenic, no lead). Mr. C. C. Cito, of Irvington, N. J., proposes to add to the ore a percentage of copper, preferably equal to two-thirds of that of nickel and cobalt, and at least the same as that of arsenic, and not less in amount than the silver. The smelting operation, yields, firstly, an alloy containing besides copper, all the silver, nickel, and cobalt, and nearly all the arsenic in the ore treated, and secondly, a slag containing a very low percentage of silver, nickel, and cobalt. The alloy is subsequently separated by electrolysis, while the slag is used as flux in the blast furnace to recover the balance of the metals. (949,059 and 949,261, Feb. 15, 1910.)

Gas-Fired Vertical Smelting Furnace.—Mr. John S. Loder, of Reno, Nevada, builds the upper section of his smelting furnace in the usual way with vertical refractory walls. Below the straight vertical upper section is placed a funnel-shaped lower section made of metal and water-cooled, and this section is provided with a projecting shoulder or bulge. The ore charged into the upper section strikes the inclined lower section and the projecting shoulder, and the intention is to support it in this way in form of an arch by the high pressure produced below the shoulder by the gaseous fuel and air charged into the furnace through burners. This is intended to provide a free combustion space in the bottom of the furnace immediately beneath the ore, so that the flame plays on the bottom of the ore, gradually melting the same, which falls to the floor. (948,098, Feb. 1, 1910.)

Utilization of Flue Dust from Smelters.—Mr. N. H. Livington, of Globe, Arizona, proposes to utilize the collected flue dust from smelters directly in a converter without first briquetting it. The dust delivered from a hopper is blown into a pipe connected to a high-pressure blower and is then blown into a large pipe connected to a low-pressure blower and discharging into the converter, where the dust mixes with the molten metal. (943,752, Dec. 21, 1909.)

Electric Furnaces.

Induction Furnace.—To reduce or eliminate the primary stray flux (which has such a detrimental effect on the power-factor of an induction furnace), Messrs. E. A. Grönwall, A. R. Lindblad and O. Stalhane, of Ludvika, Sweden, place auxiliary coils in the path of the leakage flux in such a way that the magnetic flux produced by these coils counteracts the leakage flux. Fig. 3 shows one possible method. The coil 5 with the terminals 6 and 7 is the primary. The channel 4 containing the fused bath is the secondary. The coils 8 and 9 are the auxiliary coils; in the upper diagram one terminal 10 of one coil is connected to one terminal 11 of the other; the two other terminals 12 and 13 are connected to an outside source of current. If there exists primary leakage a greater number of lines of magnetic flux pass through leg 1 than through leg 2; the e.m.f. is induced in coil 8 is greater than the e.m.f. induced in coil 9. The difference of these two e.m.fs. is proportioned to the primary leakage flux. If a suitable current is passed through the coils 8 and 9 so that the m.m.f. of the coils will equal the m.m.f. with which the primary leakage flux tends to issue from core, the primary leakage is thereby overcome. Only a small voltage is then required at the terminals 12 and 13 of the coils 8 and 9, sufficient to overcome their ohmic resistance. The current for the auxiliary coils may be taken from the primary mains, and for this purpose the "Hick transformer coupling" may be employed; this is illustrated in the lower diagram. (942,961, Dec. 14, 1909.)

Silicon Carbide, Artificial Gems.—The theoretical reaction on which the manufacture of carborundum is usually based is $SiO_2 + 3C = SiC + 2CO$, and the following proportions by weight (affording a slight excess of carbon over that theoretically required) are used in practice: 35.1 per cent ground coke, 54.4 sand, 7 sawdust, 3.5 common salt. The silicon carbide thus produced occurs in the form of opaque crystals of various colors, the black predominating. Mr. Frank J. Tone, superintendent of the Carborundum Company, has discovered another reaction $3Si + 2CO = 2SiC + SiO_2$. This

is a gaseous reaction, gaseous silicon combining with carbon monoxide at a temperature below the temperature of dissociation of silicon carbide. The silicon carbide thus produced builds up in large crystals, which start upon crystals, initially

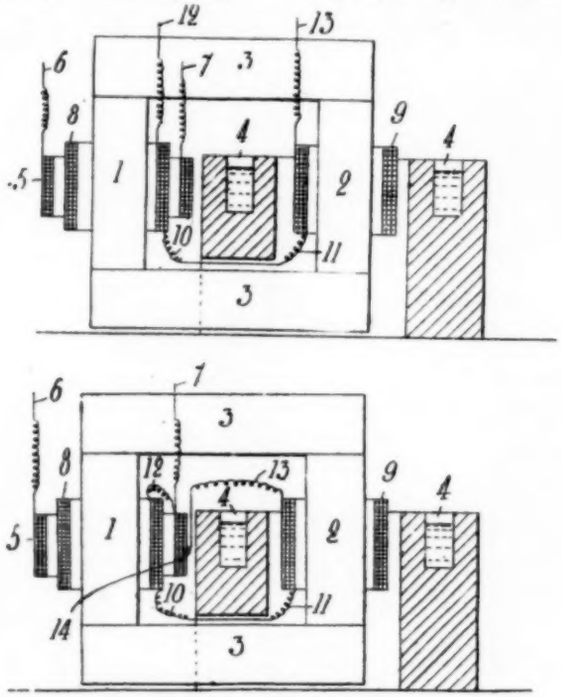


FIG. 3.—INDUCTION FURNACE.

formed by the direct union of silica and carbon of the charge, and by prolonging the operation of the furnace these crystals can be made to attain a large size. For this purpose the charge mixture should be constituted so as to afford spaces for the mingling and combining of the gases. This space is afforded by using sawdust in the charge mixture, preferably in a larger percentage than heretofore employed. Mr. Tone uses a carborundum furnace with a core of carbon, preferably in the form of carbon granules, free from contamination of metallic oxides (for instance, a carbon core taken from previous runs of a furnace). This he surrounds with a mixture of pure silica, petroleum coke (or purified ground coke), and sawdust. These are mixed in a proportion so that the silica will be somewhat in excess of the amount theoretically required by the formula

$$SiO_2 + 3\,C = SiC + 2\,CO.$$

These proportions by weight are attained by the following mixture: ground carbon, 30 per cent; silica, 57 per cent; sawdust, 9 per cent; common salt, 4 per cent. The furnace is then started and the operation is carried on for such a length of time that the zone of carborundum crystals adjacent to the core is decomposed to a considerable thickness, preferably to an extent of 2 in. or 3 in. The decomposition of these crystals results in the liberation of silicon vapor, which combines with the carbon monoxide gases in the furnace and builds up large crystals of carborundum just outside the zone of graphite which is formed by the decomposition. The crystals thus produced are clear and transparent, being free from coloration, and can be made of a large size. It is important that the carbon of the charge should not be in excess, since otherwise the crystals produced are apt to be black. These crystals have a very high index of refraction (exceeding that of crown glass and the diamond) and possess double refraction and are stated to be of great value as gems, since they can be cut with regular facets and polished. By adding to the furnace charge a small amount (not more than 0.5 per cent) of a coloring material, like oxide of chromium or oxide of manganese, the crystals can be tinted without destroying their transparency. (949,386, Feb. 15, 1910; assigned to Carborundum Company.)

Induction Furnace.—A modified form of induction furnace has been devised by Mr. MAGNUS UNGER, of Pittsfield, Mass. Fig. 4 shows it in perspective, with a plan view with connections to a polyphase system. It is a tilting furnace with two sets of primary windings 3 and 4 wound upon cores 5 and 6. Surrounding the primary windings is the furnace chamber 7. The annular furnace chambers interlink to form a central space which is used as a convenient treating chamber. As the annular channels surrounding the primary cores may be made of comparatively small cross-section without sacrificing the capacity of the furnace, the resistance at these regions will be correspondingly high, thus keeping a high power-factor and at the same time making a furnace of larger capacity than it is otherwise possible to operate with commercial frequencies. As there will be practically no current in the center of the furnace, the furnace chamber is made shallower at this point by the projection 9. However, the central chamber holds a considerable amount of the charge, which is protected in this way from excessive radiation, and the furnace has, therefore, a high thermal efficiency. The central space may be used for the introduction of comparatively large blocks of raw material, either ore or flux. The furnace may obviously be operated also by single-phase current. The design reminds one somewhat of the general arrangement of the Roechling-Rodenhauser furnace, although the pole plates characteristic for the latter are absent. (941,435, Nov. 30, 1909; assigned to General Electric Company.)

Induction Furnace.—To prevent the radiation of heat from the open top of an induction furnace and to permit the charging of the furnace when closed while facilitating full inspection of its interior, Mr. CARL GRUNWALD, of Essen, Germany, builds the secondary melting channel of oval or rhombic rather than circular form and provides it with lateral charging doors so that it is possible to inspect the entire surface of the

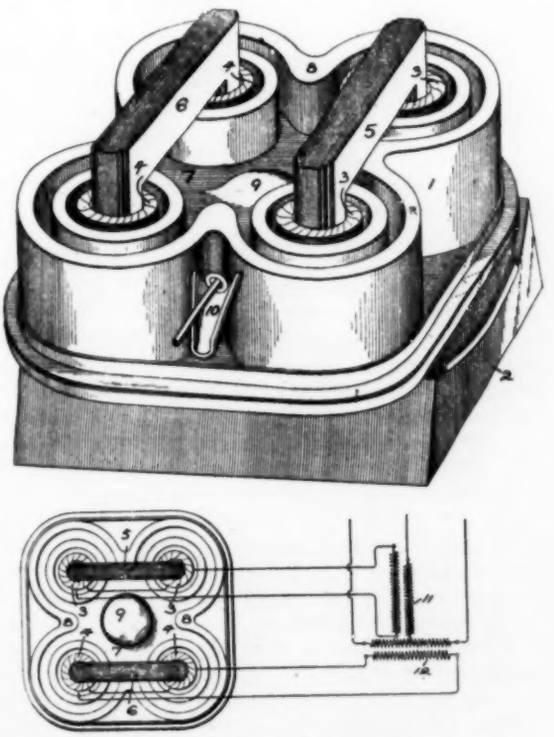


FIG. 4.—INDUCTION FURNACE.

molten charge from these two ends. (943,403, Dec. 14, 1909.)

Mixing of an Electric Furnace Charge by Pinch Effect.—Mr. A. L. QUENEAU, of Philadelphia, Pa., makes use of the "pinch effect" to produce regular pulsations in an electric furnace charge in order to thoroughly mix it. His arrangement, as applied to a three-phase furnace, is illustrated in Fig. 5, only two of the electrodes *i* being shown. The description relates

to steel refining. In this case the electrodes *i* are made of steel and are inserted in the lower ends of three narrow channels which converge upward and connect with the molten charge in the hearth *c*. With a sufficient current the pinch effect manifests itself in the channels *g*, near the upper end, a short distance below the entrance to the hearth, and will thereby cause an interruption of the molten-metal column within the channel. But the hydrostatic pressure of the heavy metal bath in the hearth will immediately close again this disruption, then it is broken again, and so on. It is emphasized that the interruptions occur at places where reducing conditions prevail so that there can be no oxidation of the disrupted surfaces. These pulsations are transferred to the molten metal in the hearth which is thereby held in constant agitation and thoroughly mixed. While the description in the patent specification relates primarily to steel refining, Mr. Queneau, who is a well-known authority on zinc metallurgy, thinks that the furnace would also be suitable with a molten metal as resistor, which is not to be refined itself, but is used as a source of heat to transmit the

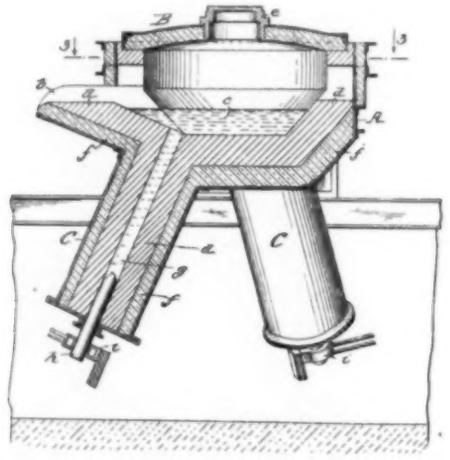


FIG. 5.—MIXING CHARGE BY PINCH EFFECT.

heating effect "to a charge of some other material superposed upon it, as, for instance, a zinc ore charge made up of the usual mixture of zinc ore and coke for the production of spelter." (948,343, Feb. 8, 1910.)

Electric Furnace for Reduction of Scruff and Dross.—Mr. Raymond S. Wile, of Pittsburgh, Pa., uses the furnace shown in Fig. 6 for the reduction of scruff and dross from tinning, galvanizing and similar operations. The metal shell 2 is lined with the refractory 3. Of the two carbon electrodes 6 and 7 the upper is movable. The dross or scruff, mixed with coke dust as reducing agent, is fed into the upper part of the furnace and rests on a bath of neutral melted material, such as glass. The upper electrode is so suspended that it just dips into the surface of the melted glass bath. The object of the melted glass bath is to collect in it the reduced metal, which is thereby protected against oxidation. The metal collects around the lower electrode and is tapped out from time to time. One chief advantage of this furnace is that the loss of metal which occurs in present methods is practically eliminated. Any metal or metallic oxides which may be volatilized in the lower portions of the charge is condensed again in the upper portions. The molten bath of glass must, of course, be of lower specific gravity than the reduced metal. (947,723, Jan. 25, 1910; assigned to American Sheet & Tin Plate Company.)

Calcium Silicide for Steel Refining.—The production of calcium silicide, which is now finding more and more extended use in steel works, is the object of a patent of Mr. Georges Strauss (assigned to Société Anonyme La Compagnie Générale d'Electro-Chimie de Bozel, of Paris, France). By heating a mixture, in definite proportions, of lime, silica and carbon in an electric furnace, calcium silicide is obtained according to the equation

$$CaO + 2\,SiO_2 + 5\,C = CaSi_2 + 5\,CO.$$

But the direct formation of silicates is a troublesome element in this process. To avoid this, Strauss uses calcium carbide (instead of lime) and metallic silicon (instead of silica) as

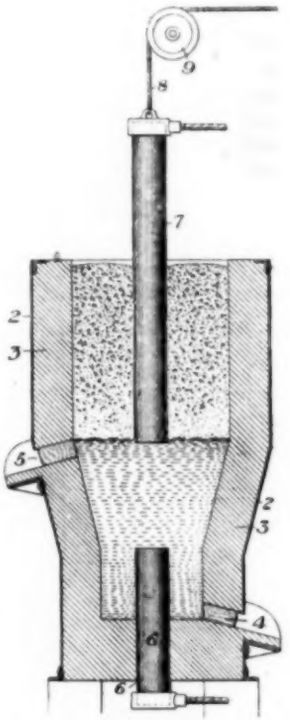


FIG. 6.—FURNACE FOR REDUCTION OF DROSS.

starting materials. He gives the following equations for the reactions:

$$CaC_2 + 2\,SiO_2 + 2\,C = CaSi_2 + 4\,CO.$$

$$2\,Si + CaO + C = CaSi_2 + CO.$$

"Experiments made with calcium silicide have shown that this metallic silicide is capable of replacing with advantage the aluminium usually employed in steel works for the purpose of preventing the formation of blow holes in steel ingots. The advantages ensuing from such application are, in addition to the economy secured by the very low price of calcium silicide, very great rapidity of reaction and the suppression of the undesirable 'shortness' which aluminium communicates to ingots of steel." (948,190, Feb. 1, 1910.)

Refining Tantalum.—While heretofore tantalum (for the manufacture of lamp filaments) has been chiefly refined by electric furnace methods, Dr. E. Weintraub, of the General Electric Company, has devised an electrolytic process for refining tantalum. A molten solution of potassium-tantalum fluoride is electrolyzed between an anode of impure tantalum and a cathode of pure tantalum or of other conductive and inert material. The impurities in the anode (carbon, tantalum, oxide, etc.) fall to the bottom of the cell. (947,983, Feb. 1, 1910.)

Electrolytic Furnaces.

Separation of Metals From Mattes or Speisses.—Messrs. E. M. Chance, of Philadelphia, and E. Kent, of Lansdowne, Pa., use the matte or speisse infused form as anode in an electrolytic furnace. The metal to be separated passes into the fused electrolyte and is deposited on the cathode. For instance, if lead, containing 2 per cent to 5 per cent of silver, is to be treated, it is molten and used as anode with a fused electrolyte of double silicate of lead and sodium. The lead passes into the electrolyte and is recovered at the cathode, while the silver re-

mains back at the anode. A second example is the treatment of copper-iron matte with fused sodium and potassium silicate as electrolyte (which may with advantage contain about 2 per cent of manganese sesquioxide to increase fluidity). If the e.m.f. is maintained below a certain critical value, only the copper is dissolved in the electrolyte and deposited on the cathode. (948,681, Feb. 8, 1910.)

Electrolytic Processes.

Electrolytic Amalgamation.—Gold in such a finely divided state that it cannot be recovered by ordinary methods is recovered by an electrolytic amalgamation process of Mr. JAMES H. ALLING, of San Francisco, in the apparatus shown in Fig. 7 in plan view, the lower diagram being a broken side view of part of it. 1 is the sluice box, which is sloped at a greater angle than usual sluice boxes. Its bottom contains a continuous amalgamating plate 2, formed at intervals into pockets or troughs 3. Each pocket has a rear wall 4 with considerable slope, a front wall 5 sloping slightly backward, and a bottom substantially horizontal. In each pocket is a quantity of mercury 7. The sides of the sluice box are formed with oblique grooves 8 inclined rearwardly upward, and across the sluice box extend amalgamating plates 9 with their edges in said grooves. These are made anodes. In addition to them there are provided swinging carbon anodes 16 suspended from bars 17 extending across between the tops of the sides of the sluice box, substantially midway between the anode plates 9. The amalgamating plate 2 in the bottom is made the cathode. The material, having been first finely pulverized is fed by a chute 23 into the top

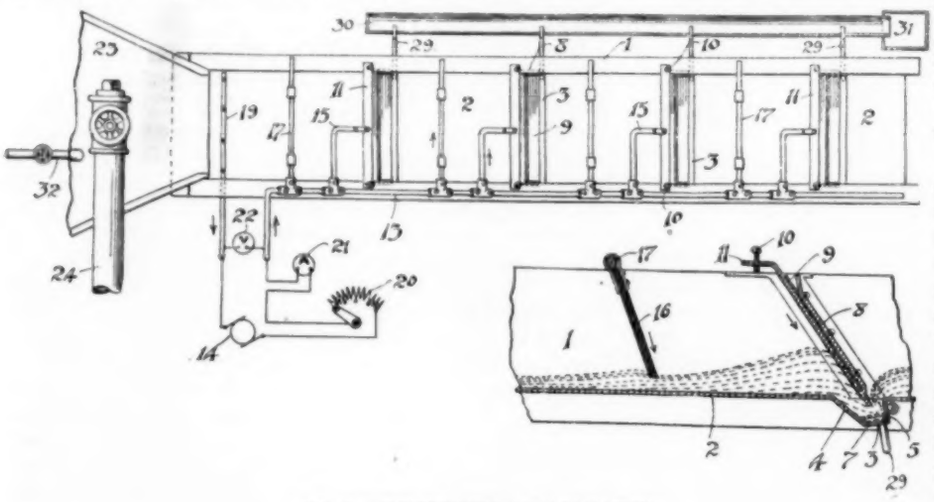


FIG. 7.—ELECTROLYTIC AMALGAMATION.

of the sluice box. At the same time there is fed, by a pipe 24, a sufficient quantity of water, about four tons to 1 ton of material, and through a pipe 32 is fed a small proportion, about 1 to 1000, 2000 or more parts of a mixture consisting of aqueous solutions of potassic cyanides and mercuric chloride. The proportion of the mixture to the water will vary according to the richness of the material being treated, the rule being to supply in the mercuric chloride 1 oz. of mercury to each ounce of gold in the material. In treating certain ores the inventor has found satisfactory proportions by weight to be ½ lb. to 1 lb. of potassic cyanide to 2 oz. mercuric chloride and 5 gal. of the solutions. The addition of the cyanide facilitates the electrolysis and cleans the gold. The density of the current used is comparatively low, being from 1/10 amp to 1 amp for each square foot of cathode surface according to the richness of the material. A tension of about 5 volts is used. It is in order to replenish the aqueous solution of mercuric chloride with mercury that the surface of the anode is amalgamated and since the mercury is continually being removed from the rear surface of the anode plates by electrolysis, as well as by the impact of the particles of gold, it is desirable to replace this mercury as fast as removed, so that there will always be a sufficient coating of mercury upon the anode plates to obtain a proper action of the apparatus. The inventor states that he has been able to save "over 95 per cent of the values of material containing finely divided gold, which cannot be saved by ordinary means." The principal advantages of the system of electrolytic amalgamation over the ordinary cyanide treatment are stated to be the saving in cost of plant and time and labor required in the process. (947,957 and 947,958, Feb. 1, 1910.)

Nickel-Copper Separation.—The old problem of separating the nickel and copper from the nickel-copper-iron sulphide ores of the Sudbury district, which has attracted so many inventors, is the subject of a patent of Dr. ADOLPHE CHALAS, of Philadelphia, Pa. The nickel-copper matte from pyrrhotite smelting is bessemerized to slag off the iron and to concentrate the nickel-copper contents to about 80 per cent. The resulting rich matte is then roasted to convert it into oxides of nickel and copper, which are finally reduced, with production of an alloy of nickel and copper. The resulting nickel-copper alloy is then cast into anodes, which are placed in an electrolytic cell, No. 1, having sheet cathodes of nickel, copper, or iron, and containing as an electrolyte an aqueous solution of an alkali-metal salt, for example, sodium chloride. The anodic and cathodic solutions are separated by a diaphragm. As electrolysis proceeds, nickel and copper are dissolved from the anodes as chlorides, while a sodium hydroxide solution is produced at the cathode. During electrolysis the solution is continuously circulated from the anodic compartment of the cell through a filter, No. 1, containing a body of precipitated nickelous (cuprous) hydroxide, which reacts upon the dissolved copper chloride with production of dissolved nickel chloride and precipitation of copper hydroxide.

The solution thus freed from copper and containing an additional amount of nickel equivalent to the removed copper is mixed with the alkali solution which continuously flows from the cathodic compartment of the cell. These two solutions when mixed react with the production of pure nickelous hydroxide, which precipitates, and sodium chloride brine. The brine, carrying the precipitate in suspension, is circulated through a filter, No. 2, which retains the pure nickelous hydroxide, the clear solution being returned to the cell to regenerate the electrolyte. When the nickel hydroxide in filter No. 1 has been completely dissolved and replaced by precipitated copper hydroxide, the stream of electrolyte from the anodic compartment of cell No. 1 is diverted to a filter, No. 3, which has been filled with fresh precipitated nickelous (cuprous) hydroxide, and the first filter is emptied, cleaned and refilled. When filter No. 2 has also been filled with pure nickel hydroxide it is also replaced by another and is emptied and cleaned for subsequent use. The pure copper hydroxide from filter No. 1 and the pure nickel hydroxide from filter No. 2 may be merely dried or calcined to give pure copper and nickel oxides. The nickelous (cuprous) hydroxide used in filter No. 1 for the precipitation of copper is produced by directly mixing the anodic and cathodic solutions flowing from an electrolytic cell, No. 2, identical with cell No. 1, so that nickel and copper hydroxides precipitate together. The brine, carrying the precipitate in suspension, is circulated through a filter, No. 3, which retains the mixed hydroxides, the clear solution being returned to cell No. 2 to regenerate the electrolyte. The nickelous hydroxide alone reacts with the anodic solution from cell 1.

Commercially five filters or sets of filters are preferably employed, which are worked in rotation; filter No. 1 containing nickel-copper hydroxide is used in the second stage of the process, while filter No. 2 is being filled with nickel hydroxide free from copper, and filter No. 3 is being filled with nickel-copper hydroxide. Filter No. 3 is then substituted for filter No. 1, an empty filter; No. 4 is used to replace No. 2, and the last filter, No. 5, is filled with nickel-copper hydroxide in sequence with No. 3, the process being cyclic and the reagents continuously regenerated. (947,791, Feb. 1, 1910.)

Electrode Construction.—Mr. John William Stubbs of Middlewich, England, patents the electrode construction of Fig. 8, showing sectional views at right angles to each other. Between a pair of copper bars *a* are disposed at intervals the cross-bars or nipples *c* of carbon. Lead *b* is then cast around the carbon nipples and between them and the copper bars *a*, thus attaching the carbon nipples firmly to the conductor bars, both mechanically and electrically. The copper bars are then coated with tar, pitch, paraffin wax, asbestos impregnated with oil, or some other impervious insulating material to prevent corrosion of the copper by the electrolyte, and are finally covered with Portland cement *g*. The ends of the carbon nipples are furnished with carbon blocks *h*. The electrodes are evidently intended for sodium chloride electrolysis. (947,358, Jan. 25, 1910.)

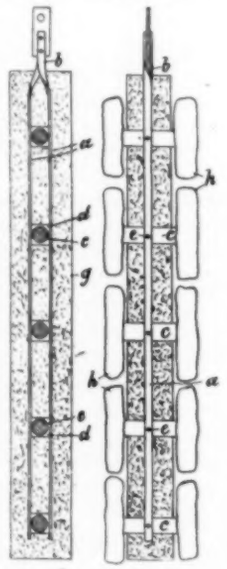


FIG. 8.—ELECTRODE.

Charging Device for Electric Furnaces.—The construction described and illustrated by Taussig, on page 46 of our January issue, is covered by a recent patent of A. Helfenstein. It relates especially to the broad openings or slots which are provided in the roof of the furnace around the charging hopper. These openings are usually tightly closed by sand-sealed covers, but they permit access to and guarding of the heating zone and entrance of the mixture in the electric melting hearth also during the charging period. They are useful for the removal of slag and crusts, for ascertaining any breaking of the electrode and for removal of the broken part. The openings permit also to introduce ingredients to correct the mixture, when disturbances occur which require an interruption of the working. They also act as safety valves in cases of too high gas pressure, avoiding so an escaping of gas through the high mixture pile in the charging pit and the charging tubes. By these slots the closed furnace possesses all advantages of an open furnace without the disadvantages of the same. For further details see Taussig's paper. (942,068, Dec. 7, 1909.)

Electric Discharges Through Gases.

Electric Furnace for Producing Nitric Acid from Air.—A peculiar furnace construction which has some points in common with that of Birkeland and Eyde, and also with that of the Badische Company, but differs essentially from both of them, has been patented by Mr. F. I. duPont (E. I. duPont de Nemours Powder Company). He uses a long tube of quartz with electrodes in both ends, between which the arc is formed. But this arc is not straight as in the furnace of the Badische Company, but is deflected and kept in rotation by means of various rotary magnetic fields. For this purpose a number of magnet systems are placed one above the other in such a way that in any system the polarities are reversed as compared with the adjacent magnet systems above and below. In this way the arc is caused to rotate and to be blown from side to side of the tube. The air, while flowing through the tube, has to pass through the arc as many times as the arc crosses over the tube, and between passages itt is cooled by contact with the quartz tube, which is cooled from the outside. (943,661, Dec. 21, 1909.)

Synopsis of Metallurgical and Chemical Literature.

Sintering of Iron Ores.—Dr. J. Savelsberg, in German patent 210,742, makes an interesting proposition for the sinter-roasting or plain sintering of fine iron ores, manganese ores, pyrites, cinders, flue dust and other metallurgical materials. He mixes them with a small amount of waste fuel, and "bessemer" roasts them in the well-known Huntington-Heberlein converter, used so successfully for self-roasting of lead sulphide ores. The fuel may be coal dust, coke breeze, lignite, peat, waste wood, etc., and 8 to 15 per cent of the weight of the ore is sufficient for the sintering. The sinter roasting burns out the fuel and sinters the material together to cakes which may be broken into any desired size, and which are very well suited for blast furnace reduction. (*Métallurgie*, Oct. 8, 1909.)

Blast Furnace Slag for Cement Making.—In the Lond. *Elec. Review* of Feb. 11, a description is given of the use of the Colloseus process for utilizing the slag of the blast furnace in cement making at the Coltness Iron Company works at Newmains, Lanarkshire. This is the first plant of its kind in Great Britain. The blast-furnace gases are utilized for operating three gas engines, two of them being for blowing purposes and the third for generating electric power for operating the ball and tube mills, conveyors, etc., in the cement mill.

Rotary Extractor for Precious Metals.—In the December, 1909, issue of the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa, W. D'Arcy Lloyd and Ernest T. Rand point out that from time to time attempts have been made to precipitate gold and silver from their cyanide solutions while the precipitating agent was in motion, with more or less success. For example, zinc shavings have frequently been subjected to mechanical motion while in contact with the gold and silver cyanide solutions and in most cases as far as actual precipitation of metals was concerned, some success has been achieved, but mechanical difficulties have developed due to the method of applying motion by attrition, etc. The main idea underlying all the attempts to perform the operation of precipitation with the precipitating agent in motion is to avoid the fouling of the zinc, which is so painfully evident in the first compartments of all extractor boxes after a three days' run from time of dressing. It is well known that after thorough washing and redressing, the zinc will go on precipitating as briskly as ever until fouling starts again. The natural inference from this is that if the zinc could be kept continuously in motion, thus preventing fouling, the highest efficiency would be maintained. With this point in view, the authors devised a rotary extractor machine, which will be described in greater detail in a later issue, and for which on the basis of the experiments the following advantages are claimed: (1) Ready access by authorized persons to the gold slimes, without stoppage of precipitation, enabling a daily clean-up to be made if required. (2) With clippings and coarsely cut filiform zinc, absence of breaking down and readiness of removal of adhering gold in an acid bath without consumption of all the zinc, with a consequent saving of zinc and acid. (3) Clean-up quick and cleanly with a consequent advantage of a minimum of loss. (4) Shortness of time rotor is out of action during dressing. (5) No fouling of zinc. (6) While in operation no danger of theft of gold slimes, as all valves would be locked. In the discussion which followed Mr. A. F. Crosse pointed out another advantage, namely, the mechanical driving off of the hydrogen bubbles from the zinc, since this removal of hydrogen helps precipitation.

An Electrolytic Zinc Process.—For some time reports have

been received on a new electrolytic process of producing zinc from ores, in which the Siemens & Halske Company is interested. This has now been described by V. ENGELHARDT and M. HUTH in *Metallurgie* of Jan. 8. The authors emphasize that if an electrolytic zinc process shall be successful the process must be very simple and the apparatus cheap and durable. The main difficulty is to maintain the zinc salt solution always in good, pure condition, since when it is fouled the deposit of the zinc becomes spongy, and besides the zinc deposited on the cathode is redissolved by the free acid. Only as long as the zinc salt solution is kept in great purity, the redissolving of the deposited zinc by the solution can be prevented. The chief difficulty of keeping the solution pure when using a sulphate solution is the selection of a proper anode material. Platinum is out of the question on account of the cost. Carbon anodes are quickly destroyed, while from lead anodes or hard lead anodes such considerable quantities of lead pass into solution that the electrolytic zinc deposited on the cathodes becomes impure and loses its resistivity against the acid. The iron oxide solutions which have been found successful in sodium chloride electrolysis are also attacked by the sulphate solution and the deposition of pure zinc is no longer possible. The first anodes that were found successful for zinc sulphate electrolysis were the lead peroxide anodes of Ferchland. By the use of these anodes it is possible to obtain a pure zinc which is not attacked by the solution even if it contains as much as 10 per cent of free sulphuric acid. In an experimental plant in Upper Silesia sulphate electrolysis with Ferchland lead peroxide anodes was carried out on a larger scale for about a year. The process was found to be technically successful. The losses of zinc are three times greater with zinc smelting than with the electrolytic process. Further, the operation showed that the purification of the solution to the desired high degree could be carried out easily and without great cost if certain precautions were taken in the making up of the solutions. With the exception of some small troubles in the beginning, the electrolysis itself was quite successful. The electrolytic zinc has a purity of 99.98 per cent to 99.99 per cent. The energy consumption was 3.9 kw-hours per kilogram of zinc. This relatively high power consumption was due to the small mechanical durability of the anodes, causing both an increase of voltage and a reduction of amp-hour efficiency. With a more durable anode material the authors figure that the energy consumption would be 3.3 kw-hours to 3.5 kw-hours per kilogram of zinc. The cost of operation per 1000 kg of electrolytic zinc was $39.25. This figure includes cost of power (0.625 cent per kw-hour), wages, material for purification of solution, remelting the electrolytic zinc, general cost, and license. But the figure does not include amortization or cost of ore. Two-thirds of the figure of $39.25 is the cost of electrical energy, so that the authors think that with very cheap power the production of 1000 kg of electrolytic zinc could be reduced to about $19.25. (Under the condition of power cost in this country this would hardly be possible, since a cost of 0.625 cent per kw-hour is already very low.) An equally excellent material for anodes for sulphate electrolysis, to be used as a substitute for the lead peroxide anodes of Ferchland, are the manganese peroxide anodes made by the process of Siemens and Halske. This material used as an anode in a sulphate solution is absolutely insoluble and is far more durable than lead peroxide anodes. Experiments made with manganese peroxide anodes for over a year have shown that these anodes will last for several years. While the Ferchland lead peroxide anodes can be made only in stick form, the manganese peroxide anodes can also be made in plate form. In spite of the comparatively successful results obtained in the plant in Upper Silesia, the process has not been introduced on a large scale. The reason is stated to be that the electrolytic process when carried out with steam power and when treating expensive high-percentage ores is economical only if the very pure electrolytic zinc will demand a considerably higher price than the commercial spelter. At present there is a margin of $50 per ton for very pure zinc. But whether this margin could be maintained for very pure zinc produced on a large scale is doubtful and it would be injudicious to build a plant on the basis of such expectations. A small margin will, however, always be maintained since the cost of rolling is considerably lower with the pure zinc on account of its great softness. The authors expect, however, that the electrolytic process can be used safely with an expectation of profit in all cases in which poorer and cheaper ores or zinc scrap are to be treated.

Protective Lime Diaphragm On Cathode; Production of Hypochlorites and Chlorates.—In the electrolysis of aqueous solutions for the reduction and oxidation of chemical compounds it is important to prevent the cathodic reduction products from being oxidized again by contact with the anode and to prevent the anodic oxidation products from being reduced again at the cathode. The old ordinary diaphragm cell has distinct disadvantages in many cases. A modification—in which a diaphragm close to and adhering to the cathode is produced automatically during electrolysis in the cell—has been found useful for the production of hypochlorite and chlorate. Thus H. Bischoff and F. Foerster found in the electrolysis of alkali chlorides for hypochlorite production that an addition of calcium chloride greatly diminishes the cathodic reduction of the hypochlorite formed; this is due to the formation of a layer of lime on the cathode which prevents direct contact between the hypochlorite and the cathode. E. Mueller has later shown that an addition of potassium chromate is even more effective; it results in the formation of a chromium oxide diaphragm which prevents any cathodic reduction whatever. The use of an addition of calcium chloride in the commercial manufacture of hypochlorite and chlorate has failed because the diaphragm formed at the cathode would not stick to it with sufficient rigidity. E. MÜLLER and M. BUCHNER have now found (*Zeit. f. Elektrochemie*, Feb. 1) that they can produce a firmly adhering lime diaphragm on the cathode by adding a very small quantity of a colloid (gelatine, etc.) to the solution to which calcium chloride or chromate has been added. This effect of the colloid seems to be the same as in the Betts lead refining process, where the application of a very small amount of a colloid results in a firm adhesive deposit of lead.

Ammonia-Soda Process.—A recent lecture by Prof. A. COLSON, of Paris, before the Society of Chem. Ind. in London is noticed in Lond. *Eng'ing*, Feb. 11. "Prof. Colson is manager of the St. Cobain Alkali Works, in which the ammonia-soda process is used. Professor Colson dealt in his lecture with the present state and possible modifications of the ammonia-soda process. The lecturer stated that the value of the soda produced by the process was about £2,000,000 annually; owing to the salt duty, France produced only $1,500,000 worth—less than England and Germany. Four operations might be distinguished: The decomposition of limestone into quicklime and carbon dioxide; the precipitation of sodium carbonate from ordinary salt solution by means of ammonia and carbonic acid; the calculation of the sodium bicarbonic to carbonate (soda); and the regeneration of ammonia from the chloride formed by means of caustic lime. The ammonia played an intermediate, though most important part. The total heat balance of the whole reactions was the evolution of 5200 calories, but 44,500 calories were required for decomposition of the limestone and coal was hardly required for the other reactions." There were many difficulties in the different operations more perhaps for the engineer than for the chemist, for the chemistry was well understood. For instance, the pumps drawing off the carbon dioxide were rapidly destroyed by the gas and the flue-dust. The precipitation of the bicarbonate had to be rapid lest a double carbonate of ammonium and sodium be formed or some ammonium chloride be precipitated with the carbonate; the latter would be destructive to the cal-

cining plant. The regeneration of the ammonia was now effected by quicklime, not by milk of lime, and the ammonia was absorbed by water. The operation took place in column apparatus, such as were used for the rectification of alcohol, but they were much larger, as volumes of 15 and 20 cubic meters had to be dealt with per hour. In one case gas discharge pipes of insufficient cross-section had caused very serious trouble. It was also most essential to secure actual contact between the lime and the ammonium chloride. In some French works solid salt was the raw material of the soda; in others brine was used, which was exclusively applied in England. The process as worked in various Solvay works was now considered almost perfect, especially after the introduction of machinery to replace manual labor; that, however, required large capital. More than 2.5 kilogrammes of ammonia should not be lost in the cycle of operations if the process were to pay. Professor Colson then explained that his various experiments had been conducted not so much with the object of improving the various operations as with the object of suppressing some of them. He proceeded to show how this could be done when sodium nitrate was substituted as raw material for the chloride (ordinary salt). The by-product would then be a mixture of sodium and calcium nitrates, which was as valuable almost to agriculture as the original Chili saltpeter. "The discussion of the paper was disappointing. One gentleman employed in the ammonia-soda industry said that he had almost been afraid that Professor Colson might give away some of the secret manipulations by which the troubles were overcome. One cannot help feeling that the discussions in our engineering and electrical societies, in which trade secrets used to be so jealously guarded, have of late years risen to a higher level."

Copper-Aluminium-Manganese Alloys.—The 8th report to the alloys research committee of the (Brit.) Inst. Mech. Eng., by Carpenter and Edwards, dealt with copper-aluminium alloys. This has now been followed by the ninth report, by W. Rosenhain and F. C. A. H. Lantsberry, of the Nat. Phys. Laboratory, on the effect which an addition of manganese has on the properties of copper-aluminium alloys. Broadly speaking, the ternary alloys, of which the principal ingredient is copper, when compared with the best binary alloys of copper and aluminium, present certain advantages, having a higher yield-point, a slightly higher ultimate stress, and undiminished ductility. The alloys were tested in the form of sand castings, chill castings and rolled bars. One alloy proved best in one form, while others surpassed it under other conditions. These alloys showed improvement in the rolled form over the chill-castings, especially in elongation. Certain alloys examined by dynamic test prove these particular ternary alloys to be practically equal to the binary alloy containing 10 per cent Al, but they show a very slight inferiority as regards the safe range of alternating stresses. On the other hand, under impact test some of the ternary alloys gave remarkable results—very remarkable ones, indeed—under the abrasion test in Dr. Stanton's machine. As regards corrosion in salt and fresh water, the ternary alloys are equal, and in some cases rather superior to the copper-aluminium series. With regard to the alloys at the light end of the series the results of the present investigation are not so favorable. In the case of one of the series the tests on chill-castings gave good tensile strength and elongation, but rolled bars of the same alloy showed no better results than those obtained with copper-aluminium alone. The temperature at which the metal is poured greatly influences the properties of these alloys. An almost complete reprint of this very long, illustrated report begins in Lond. *Engineering* Jan. 28.

A New Plating Method.—A new method of plating was described by Mr. A. Rosenberg in a recent lecture before the Society of Arts in London. (Lond. *Electric Review*, Feb. 11.) The desired metallic coating is produced by simply rubbing the surface with a paste made of a prepared powder. While the process is therefore simply one of rubbing the metal in, its principle is electrochemical. The rationale of Mr. Rosenberg's process is this: His plating powders are compounded of: First, some form (whether elementary or combined) of the metal to be deposited; secondly, an uncombined electropositive metal, usually magnesium, but sometimes aluminium, zinc or cadmium, in a highly divided state of division; thirdly, a substance capable of producing an aqueous electrolyte when brought into contact with moisture (this ingredient is only necessary when the metal to be deposited is present in the metallic state); and lastly, certain inert substances such as chalk, soapstone, kieselguhr, boracic acid, dextrine, etc., whose function is to act partly as diluents, to prevent premature too rapid action, and partly as polishing materials. It is clear that if a mixture of the above ingredients is moistened and rubbed over a clean metallic surface, an innumerable number of infinitesimal voltaic cells will be produced, and while the electropositive metal present—the magnesium, for example—will go into solution as anode, the metal of the salt present will be deposited on the surface under treatment, which acts as cathode, and as the paste is rapidly rubbed over the whole surface, a continuous metallic coating will be electrodeposited in the literal sense of the term. The following simple experiment may be made as an illustration. Rub a mixture of magnesium power (2 parts), and powdered nickel ammonium sulphate (20 parts) with a moist rag over a copper penny. This will immediately become coated with a bright film of nickel.

Further, to illustrate the reactions, take the mixture recommended for the deposition of zinc: Zinc dust, 15 parts; ammonium sulphate, 5 parts; magnesium, 1 part; chalk, 10 parts; soapstone, 2.5 parts. In this case it is advisable to use the zinc in the metallic form, and both magnesium and zinc will go into solution electrolytically forming their respective sulphates, while zinc will immediately be thrown out of solution again, as the action proceeds, and deposited on the cathode, namely, the object under treatment. The function of the soapstone in this instance is to prevent the mixture from absorbing moisture if exposed to the air. The chalk is useful both as diluent and as a polishing agent. It is further useful as a source of alkalinity, which, just as in ordinary plating, may be valuable in improving the color and quality of the deposit. The object to be plated has to be reasonably clean and free from grease, but the operation itself involves both mechanical and chemical cleaning, and hence the great precautions taken to clean the work in ordinary electroplating can be dispensed with in the new process. At the same time, the brighter and more highly polished the surface to be plated the brighter will be the deposit thrown down. The plating powders are being placed on the market under the name of "galvanit." At present only silver, nickel and tin mixtures can be obtained; but the list is to be extended, and will include alloys like brass and gun-metal, which, it is stated, can be plated with ease. It appears that the mixtures if kept in a fairly dry place do not deteriorate with time on account of local chemical action being set up; this is prevented partly by the presence of the inert substances referred to previously; and partly by coating the magnesium powder with a thin film of paraffin or resin, by immersing it in a volatile solution of these substances. The friction involved in the plating process is sufficient to remove the insulating films from the magnesium when that is no longer required.

Electrode Losses in Electric Furnaces.—In an appendix to his paper on electrode losses, just published in Vol. XVI, of the *Transactions* of the American Electrochemical Society, Mr. Carl Hering gives the results of an experimental determination of his mean conductivities and resistivities between 100° C (cold electrode end temperature) and 900° C. (furnace temperature). In the inch units specified in his article in our last October issue they are: graphite $r = 0.000323$, $k = 0.740$; carbon $r = 0.00148$ and $k = 0.329$.

The Wood-Distilling Industry.

BY CHARLES L. CAMPBELL.

The rapid growth of the wood-distilling industry in this country from its start up to within the last two years, and recent developments in this industry in affecting it, taken together with the fact that there is no literature in the English language covering the subject to any extent, would seem to warrant at this time a brief review of the subject and a look at its future.

Historical.—The wood-distilling industry is a very old one, the subject being mentioned in the writings of the old Romans. The distillation was very crude, however, being carried on for the purpose of obtaining charcoal alone, and it was not until 1835 that any considerable advance was made in the industry. At this time Dumas and Poligot, in Europe, investigated the constitution of the vapors given off from the wood during distillation, and recognized the three principal constituents: acetone, methyl alcohol and acetic acid.

Other investigators examined the tar and gases formed, the gas, which usually contains about 30 per cent to 35 per cent of methane, CO, etc., being used by Lebon for lighting in some German towns. These investigations mark the beginning of the modern wood-distilling industry, although the first wood-distilling plant was started at Hausach, in Germany, in 1819, and a man named Adams established a plant at North Adams, Mass., in 1830, where the vapors constituting the pyroligneous acid were recovered.

The coal-tar industry in Europe, which began in 1856, at the time of Perkin's discoveries, marked the beginning of the modern epoch in wood distillation, since the production of coal-tar colors required the use of methyl alcohol and acetic acid and brought about the extensive refining of the pyroligneous acid after its recovery. This industry was, however, confined mostly to Europe, and the subsequent developments in organic chemistry, in which Germany was the leading factor, requiring the refined products of wood distillation, made her the center of this refining industry.

The industry in the United States, however, developed much more slowly, the first wood-alcohol refinery being founded in 1874 at Binghamton, N. Y., by G. C. Edwards. The industry in this country at that time was mostly for the purpose of producing charcoal for fuel or for making charcoal iron, in contrast to the German industry, where the refined products were the objective. It was, therefore, natural that the raw products of the industry in this country should be shipped to Germany, and such was the case, the record of import showing that in 1897 Germany imported an amount of raw materials from the wood-distilling industries equal to twice her production. This state of the two industries, American and German, has continued up to the present time, America exporting in 1908 one-third of its production of raw wood alcohol and large amounts of acetate of lime, but a change has been coming about and indications point to decreased exportation from and increased refining in this country.

Present Methods.—In order to understand where the industry in this country stands at present and the opportunities open to it in the future, a brief outline of the process used in the great majority of American plants will be given. In this country at the present time there are probably about 150 plants, ranging in size from 500 to 250,000 cords per day. In 1907 the following plants reported their yearly consumption and output to the Department of Agriculture:

States.	Number of plants.	Cords per year
Michigan	13	602,000 cords.
New York	28	127,000 "
Pennsylvania	53	358,000 "

However, while these three States support the majority of plants in the wood-distilling industry, yet there are many plants in other States which were not reported to the Department of Agriculture. This list also does not include the plants distilling pine woods for the purpose of obtaining oil of turpentine.

Of the processes used in these plants there are a great many modifications, and it would take a good-sized volume to discuss them all, but a thorough investigation has shown that of these special processes a majority have either failed entirely or worked unsatisfactorily.

There are two distinct processes in use at the present time, i.e., destructive and steam distillation, but the latter is a small industry as compared with the former and cannot be considered at this time. The destructive process in general use consists in heating the wood either by external heat or by partial combustion so that the wood-fiber material is broken down, the products yielded being:

(1) Charcoal.
(2) Tar.
(3) Watery distillate, pyroligneous acid.
(4) Uncondensable gases.

The object of the distillation is the recovery of one or all of these products, the amounts of same being dependent on the wood and the process used.

The destructive distillation process for which the principal kinds of wood used are beech, birch, maple and oak, and may be divided, in turn, into two distinct parts, the "kiln" and the "retort" processes. In the "kiln" process the primary object of the distillation is the production of charcoal, usually for making iron, and the center of this branch of the industry is in Michigan. The kiln is a bee-hive shaped brick retort, holding anywhere from 15 to 120 cords of wood, the kiln being packed by hand and heated by burning the wood with an insufficient supply of air, or by burning the uncondensable gases formed during the distillation, the kiln in this case being fitted with heating pipes in its interior and sometimes lined with metal. The time of distillation may be as much as three weeks, and the vapors which are given off are usually recovered.

In the "retort" process the object of the distillation is usually the recovery of charcoal and pyroligneous acid, as well as tar and gases. The retorts are made of iron, and are set in brickwork. They are of all shapes and sizes, the main types being:

(1) The small, upright, removable retort, packed by hand.

(2) The small, horizontal, cylindrical retort, fixed in position, and filled and emptied by hand.

(3) The large, horizontal, square or cylindrical retort or oven, fixed in position, and filled and emptied mechanically, the wood being in most cases packed on cars and these cars being wheeled into and out of these retorts.

Of these retorts type No. 1, the small, upright oven, is probably most used. These retorts may be heated by coal, wood or tar, or by the gases obtained in the distillation.

The vapors given off during the distillation are condensed by devices of some sort, various arrangements being made, but the main types are the coil, box and upright tubular condensers. The uncondensed gases are led by suitable pipes to be burned under the retorts without further treatment. The crude pyroligneous acid obtained contains approximately the following constituents:

Tar and tar oils	9.8 per cent.
Acetic acid	10.0 "
Methyl alcohol	3.0 "
Acetone	.2 "
Water	77.0 "

also propionic, valerianic and butyric acids, allyl alcohol, aldehyde, furfurol, ammonia, methyl acetate, methyl-ethyl ketone, amines, and pyridine bases, etc.

Further processes have to do with the removal of the various products from each other, and conversion into a commercial form. The tar and oils are removed for the most part by allowing the crude pyroligneous acid to settle, by which operation three distinct layers are formed, the lower one con-

sisting of tar with creosote oil and some pyroligneous acid; above that the pyroligneous acid containing considerable amounts of dissolved tar; and on top the lighter hydro-carbon oils.

By a proper arrangement of taps these different layers can be separated from each other and collected in separate tanks ready for subsequent operations.

The tar-containing pyroligneous acid is re-distilled in a steam-jacketed or coil-heated pan, by which operation the tar is left as a residue and vapors containing acetone, wood alcohol, acetic acid, water, and slight amounts of other impurities are formed. These vapors are passed into a milk of lime solution containing about 20 per cent CaO, by which process acetic acid is removed from these vapors and a weak solution of calcium acetate with some tarry impurities is obtained.

The unabsorbed vapors, consisting mainly of alcohol, water and acetone, may be condensed to give a weak alcoholic solution, or may be passed through a concentrating apparatus, consisting usually of water-cooled bonnets, to give a 35 per cent to 40 per cent solution of wood alcohol. The solution of acetate is heated to remove the last traces of alcohol, the alcoholic vapors so formed being united with the others, and the impure solution is then filter-pressed to remove dirt, excess lime, etc., and finally evaporated, first in comparatively small, open, steam-jacketed pans until a thick paste or moist cake is obtained, then in open, shallow iron pans set in brickwork over the retorts until an acetate of lime of 80 per cent to 82 per cent, containing a small percentage of moisture, is obtained.

The manufacture of brown acetate by direct neutralization of impure, settled, pyroligneous acid, with milk of lime, is unimportant, the amount of this acetate manufactured being equal to only 1 per cent of the amount of gray acetate.

The 35 per cent to 40 per cent impure acetone-containing wood alcohol obtained as described is further concentrated in a column still heated by steam coils to give an impure 80 per cent by volume solution, which is not refined at the distilling plant, but in special refiners. The charcoal, which is left in the retort, is removed and cooled in a different manner according to the character of the oven used. With the small, removable retort the whole apparatus is lifted out of its setting and the charcoal either left to cool in the retort itself or dumped ino a cooling receptacle. With the small, horizontal fixed retorts the charcoal must be removed by hand from these retorts and placed in a closed receiver to cool. From the large horizontal retorts, however, the charcoal may be removed on the cars into cooling receptacles of suitable size, and when cool may be dumped from these cars where required.

The tar, whether settled out of the pyroligneous acid or removed from it by distillation is in the majority of plants burned under the retorts by suitable arrangements.

This outlines the procedure required for the production of the principal products—gray acetate of lime of 80 per cent to 82 per cent; crude wood alcohol of 80 per cent; charcoal, tar and oils.

These products are then sold to various consumers, either to chemical manufacturers and refiners, iron men and fuel consumers, or for export. Of these products the acetate of lime is used for the production of acetone, acetic acid and various acetates; the crude wood alcohol for the production of formic acid; the refined wood alcohol, pure methyl alcohol or denaturing spirits, and the tar and oils for various purposes.

The amounts of the various products yielded in the distillation process per cord of wood depends, as was mentioned before, upon the kind of wood and the process. This can be shown very well by comparing the average yields returned by the plants of Pennsylvania, where the "retort" process is used, and the object of the distillation is the recovery of all of the product; with those returned by the plants of Michigan, where the "kiln" process is used, and the object is the production of charcoal for use in making charcoal iron. The following figures show this:

State	Process used.	Products per cord.
Pennsylvania	Retort	200 lb. gray acetate of lime.
		10 gal. crude alcohol (80 per cent)
		50 bu. charcoal.
Michigan	Kiln	50 lb. gray acetate of lime.
		4 gal. crude alcohol (80 per cent).
		40 bu. charcoal.

Financial Situation.—The previous outline has given the main details of the process used in distilling wood in America to-day, and in order to understand the present situation of this industry as an investment, the following figures are given, these figures showing the average cost per cord of wood for the years 1906, 1907 and 1908; also the value of the principal products produced during that time.

	1906	1907	1908
Wood per cord (sawdust included)	$3.24	$3.14	$3.09
Wood per cord (sawdust not included)	3.69	3.62	3.57
Charcoal, per bushel	.065	.076	.071
Crude alcohol, per gallon	.340	.149	.172
Gray acetate, per pound	.021	.019	.015
Brown acetate, per pound	.012	.012	.008
Iron acetate, per gallon	....	....	.095
Oils, per gallon	.080	.024	.066

From this table it can be seen that while the price of wood has decreased a very little, the value of the products produced has decreased a very great deal, notably in the case of the crude wood alcohol.

Now this decrease in the value of the products of the wood-distilling industry is due to two factors:

(1) The financial depression of 1907.

(2) The passing of the denatured alcohol acts of 1906 and 1907.

The price of refined wood alcohol was in 1906 about 75 cents per gallon, while that of grain alcohol was about $2.40 per gallon. There are many chemical processes, such as, for instance, the hat and varnish industries, where either refined wood alcohol or grain alcohol can be used, and the cheaper is, of course, preferred. When the denatured alcohol act was passed the price of grain alcohol denatured for industrial purposes was considerably below 75 cents per gallon, and, of course, replaced wood alcohol where possible. The demand for this wood alcohol having diminished, its price naturally fell and carried with it the price of crude wood alcohol, acetate of lime and other wood products, and drove a number of wood distillers out of the business, at the same time seriously threatening the whole industry in this country. At the present time, however, it has recovered somewhat, and the outlook is bright for the future, as will be shown later.

One, and the principal denaturant, prescribed for grain alcohol is wood alcohol, containing certain impurities, and a large amount of such wood alcohol is consumed in this country. The use of denatured alcohol has not become, however, so general here as was expected, but it is probable that there will be a large increase in consumption in the future and that the consumption of wood alcohol for denaturing will be such as to use up all of the supply available for this purpose, thus restoring the prices to their former level. This situation is exactly like that in Germany 20 years ago, when the denatured alcohol act proved a boon rather than a deathblow to wood distillers and refiners.

This was for the reason that there are many purposes, for instance, in the aniline industries, for which very highly refined wood or methyl alcohol only is suitable, in which industries, therefore, the passing of the denaturing alcohol act had no effect upon the demand for wood alcohol. The use of denaturing spirit which required, as mentioned above, a very impure wood alcohol, containing various impurities, such as acetone, allyl alcohol, pyridine bases, etc., thus permitted the pro-

duction of a very pure spirit by distillation and permitted the utilization of the impure first and last runnings as denaturing spirit.

It can be seen that this was a very economical process, since such pure, refined methyl alcohol commanded a very high price, and the demand for denaturing spirit was such as to cause this to sell at a considerable profit. While industries which demand this pure alcohol have not been developed to a great extent in this country, yet there is every prospect of great development along these lines and this fact, together with the prospect of increased consumption of denatured alcohol and the probability that the amount of raw spirit produced here will not be increased, at least for a good many years, makes the outlook for wood-alcohol producers and refiners very encouraging.

While, therefore, it is thought for this and other reasons, particularly the situation of the acetic-acid industry, that the depression in the wood-distilling industry is but momentary, yet recovery will take several years, and in the meantime it will be necessary for the wood distillers to make their processes profitable. This can be done in various ways, which will be outlined. It is a fact well known that the wood-distilling industry has been conducted, at least in this country, by men unacquainted for the most part with the fundamental principles of chemistry and engineering, who have been unable or reluctant to introduce any considerable improvements into their processes, and as a result have been using up to to-day the methods of 30 years ago. With the increased costs of fuel, labor and raw materials it is evident that improvements are necessary to maintain the industry in its proper position, but in the wood-distilling industry it is notably the case that improvements which advances in the chemical industry should have made possible have not been introduced.

Improvements.—The rest of the article will be taken up with an outline of the opportunities open to distillers to so improve their plants or processes as to increase their returns in accordance with the following conditions, or to extend their business to more profitable fields. The conditions which are necessary are that they must either

(1) Increase their yield of products or the quality of the same;

(2) Reduce the costs of production either as regards fuel, labor or apparatus.

Each of these conditions will now be discussed separately.

(1) *Increasing the Yield.*—The yield depends on:

(a) The kind of wood.
(b) Condition of the wood.
(c) The form of retort and setting.
(d) The method of heating.
(e) The methods of recovering and treating the products.

As regards the kinds of wood, this method cannot change, but a proper selection will have much to do with the yield obtained. The condition of the wood, however, is very important. The moisture in the wood not only requires heat for evaporation, but, when the temperature of carbonization is reached, causes side-reactions, which result in the formation of gas instead of liquid vapors, thus decreasing the yield of pyroligneous acid to a considerable extent. In this connection only wood which has been air-dried for a year at least should be used, but a further improvement, recently introduced, consists in artificially drying and forewarming the wood before carbonizing, but after packing on the cars, if the large retort is used, by placing these cars in ovens through which the warm or hot-fire gases are passed, for 24 hours before introduction into the retort. This is done practically free of cost.

The form of retort and the setting is very important. In the first place, only large retorts which can be filled and emptied mechanically should be used. This results in a great saving of time and labor. Again, these retorts should be so placed in the setting that they can be heated uniformly over the whole length, and the heating should be so controlled that the temperature is maintained at a constant point and the heat applied slowly. It has been proven by many experiments that rapid heating results in the formation of larger amounts of gas and smaller amounts of pyroligneous acid, while slower heating decreases the yield of gas and increases the yield of acid.

The methods of recovering the products influence the yield to a considerable extent, and in this connection there should be mentioned the use of an exhauster to create a slight vacuum in the retort, thus preventing leaks, and the use of a scrubber whereby the uncondensed gases are caused to pass through a tower and are deprived of any pyroligneous acid vapor which they may contain. This may seem a small matter, but it has been found that by the use of such apparatus the yields of acetic acid and alcohol can be increased 3 per cent to 4 per cent.

(2) *Decreasing the Costs of Operation.*—To decrease these costs there may be used any appliances which tend to:

(a) Decrease the amount of labor required.
(b) Decrease the amount of fuel required.
(c) Decrease the cost of apparatus and depreciation on the same.

We have already considered these items in connection with the carbonizing itself, recommending large retorts, mechanical loading and unloading, together with the use of artificially dried wood as savers of labor and fuel in this part of the operation. Regarding methods of decreasing the costs of labor, fuel and depreciation in the remainder of the wood-distilling operations it might be well to describe the appliances and methods which can replace those now in use, and to then take up the effect of using this apparatus on the above-mentioned costs.

Practically all of the evaporation required in the operation subsequent to the carbonization is accomplished by the use of high-pressure steam, and of this steam required approximately 40 per cent is needed to re-distill the pyroligneous acid to remove the 8 per cent of tar contained in it. Now if this tar could be separated from the pyroligneous acid vapors as they came from the retort without condensation, and the tar-free vapors then passed into the milk of lime, this 40 per cent of fuel would be saved. Such an apparatus has been devised and has been in operation in many plants abroad and a very few in this country for over two years. It has actually been found to almost completely separate the tar from the vapors.

This apparatus, which operates on practically the same principle as a fractional distilling column, yields liquid tar free from acid and a tar-free pyroligneous acid vapor, and is so constructed that it requires no troublesome hand cleaning. The apparatus is not known to any extent in this country, but is destined to occupy a big field. Because of the economy of steam, it permits the formation of a very pure acetate of lime, does away with the condenser and tar still, with all the trouble of cleaning the same. This apparatus occupies little space, is simple in construction, and yields a tar which can be used for producing creosote and other tar derivatives without further treatment.

Another very important appliance, but very recently introduced, is an apparatus by means of which the acetate of lime solution containing traces of alcohol is de-alcoholized, and at the same time the weak alcohol vapors concentrated to give a product, directly, of 90 per cent to 95 per cent, and requiring only the use of the heat of the alcohol vapors and sometimes exhaust steam to accomplish the evaporation. This apparatus works on the principle of the continuous distilling apparatus used in the grain-alcohol distilleries of to-day to a large extent, the wood alcohol produced being analogous to the high-proof spirit delivered from these continuous distillation columns and the de-alcoholized acetate of lime solution to the "slop" from the same.

Special modifications are required in this apparatus, however, to meet the new conditions, but it has been found to work very satisfactorily indeed. In operating this apparatus, the acetate of lime solution is introduced into the first distilling column

after passing through a "heater," while the weak alcohol vapors are passed into the bottom of the same column, thus furnishing the necessary heat for the distillation. The vapors of wood alcohol and water, passing from the top of this column, then go to a second rectifying column and are concentrated to the required proof.

By means of this apparatus and the tar separator, it is possible to do away with the customary "three-still system," also with the wood alcohol concentrating and rectifying apparatus, and by use of the latent heat of vaporization of the weak alcohol vapors for the de-alcoholization of the acetate of lime solution, a saving of fuel amounting to 20 per cent is effected. Besides the saving in fuel, there is a saving in space and labor required, as well as a decreased cost for the first installation.

In the evaporation of the acetate of lime solution great improvements have also been made. The customary method of carrying out this evaporation, as previously described, in open pans, required high-pressure steam, much hand labor for transferring the material and cleaning the pans from incrusting materials, and gave a poor product if not carefully carried out. To do away with this, an apparatus, essentially a form of triple effect with special devices to meet the requirements, has been introduced, and in consequence of the use of a vacuum, the use of exhaust steam is possible.

This apparatus, working continuously, takes the weak of acetate of lime and delivers it in the form of a thick mush. In consequence of the fact that this apparatus permits the use of exhaust steam from the engines instead of the high-pressure steam required by the former method, there is effected a saving of approximately 100 per cent in the amount of fuel required for this operation, while the labor cost is greatly diminished and a better product is obtained. It is needless to say that this apparatus requires less room than that required by the open-pan method, and it is also a fact that the initial cost and depreciation are less in consequence of the fact that no cleaning and scraping are required on the same.

Further than this, improvements have been made in the method of drying this acetate of lime. Where it was formerly dried in the open pans over the retorts, rotary dryers, especially designed for the purpose, can now be obtained. By the use of a dryer heated by superheated steam the mushy acetate of lime is dried to give a moist cake containing 25 to 30 per cent water, which cake is then thoroughly dried in a second apparatus, also rotary, through which hot air, heated in turn by the hot retort gases, passes, and the dry acetate of 80 to 84 per cent, nearly white in color, is delivered by an elevator to a chute from which the sacks can be filled. The essential saving effected by this last apparatus is in labor and space. The labor required is never over 30 per cent of that required by the open-pan method, while the space occupied by the dryers is very much less.

Summarizing the results which may be obtained by the installation of this improved apparatus, it may be said that that amount of coal required for steam production in the plant will be reduced to 35 or 40 per cent of that required by the present customary process, the labor to one-half, and the initial plant cost for a fifty-cord per day plant to two-thirds that of plant operating under the present methods, while the cleanliness of the plant and space required for the apparatus is also affected. In every case the improved apparatus operates on principles identical with those employed for different products in other industries, with suitable modifications to meet the conditions.

It is evident that the old method now used to a great extent cannot compete for a minute with this improved process. As regards the yields, these are also increased by approximately 10 and 15 per cent. While these improvements have scarcely been introduced into this country, they have been thoroughly tested out abroad, and several plants, notably one large plant in Michigan, distilling over 200 cords per day, are to be remodeled to employ these processes during the coming year. It is to be hoped that persons engaged in wood-distilling industry in this country will not hesitate to adopt these methods and put themselves in position to compete with those who are awake to their opportunities.

* * * * *

The foregoing has related to the manufacture of the crude products of the wood-distilling industry, but the field in which extensive profits are now being reaped and where more extensive profits will be reaped in the future is in the manufacture of the finished products from these raw materials, that is, more particularly, acetic acid, refined wood alcohol, methyl alcohol, acetone, tar derivatives, and various other products, such as red and black liquors, sugar of lead, sodium acetate, etc.

Acetic Acid.—This acid, manufactured commercially from acetate of lime and a strong acid by various processes, is used in the coal tar color industry, in the dyeing and mordanting industries, in the manufacture of artificial vinegar, etc. The manufacture of this acid under improved and economical processes, yielding acid which gives the highest returns, has been in the hands of five large chemical factories up to this time, and it has been a well-known fact that the business is very profitable.

At the present time wood-distilling people producing sufficient acetate to keep an acetic acid plant of economical size in operation in localities adjacent to the large cities, for instance in Pennsylvania, are offered unexcelled opportunities in this industry. There are a number of small firms who have started plants making acetic acid, but without exception they have installed the process using small fire-heated decomposing retorts, and inefficient methods, which require the use of a large excess of raw materials and produce an inferior product, besides increasing the amount of labor required, etc.

An American firm, E. B. Badger & Sons Co., of Boston, has undertaken the installation of acetic acid plants, employing the most improved and efficient methods, notably the use of very large decomposing retorts and a vacuum system such that the fuel cost is decreased, better regulation made possible, a very much better product produced, and increased yields obtained, these improvements being sufficient to make the difference between small and large profits.

Wood distillers who follow the example of two or three plants in Pennsylvania now installing such apparatus will be well repaid. The above-mentioned firm is also in a position to supply the necessary apparatus for the following industries, in all of which they furnish the most improved type:

Refined Alcohol.—The refining of wood alcohol and the production of pure methyl alcohol is an industry where there is great opportunity for improvement in the methods and apparatus used in the majority of plants, also where wood distillers have a good chance for investment.

The refining of crude wood alcohol in this country has been controlled by a syndicate, and what they did not refine has been shipped abroad. The following table of exports shows that a large amount has been exported, also shows the drop in value of this alcohol within the last two years.

Year.	Quantity Exported.	Value.	Value Per Gal.
1902.....	627,000 gals.	$338,000	$0.54
1903.....	834,000 "	453,000	.54
1904.....	1,194,000 "	585,000	.49
1905.....	1,097,000 "	603,000	.55
1906.....	781,000 "	466,000	.60
1907.....	2,150,000 "	862,000	.40
1908.....	1,958,000 "	819,000	.42

As may be observed, the higher the price, the less alcohol exported, and vice versa.

With the present low price of crude alcohol and the demand in this country for refined wood alcohol and pure methyl alcohol, and probably soon denaturing spirit, it is absurd for distillers of sufficient size to support a refinery to sell their

crude product. They should install a refinery of their own independent of the trust, as several plants have done to their great advantage. In this industry, however, as in all others, it is necessary in order to conduct it profitably to use improved methods and apparatus. In the manufacture of refined wood alcohol, that grade known as English wood spirit is a spirit obtained by concentrating the crude wood alcohol to such a point that it contains only a small amount of water, not over 5 per cent, but still contains many of the impurities of the crude alcohol.

In the manufacture of this grade large continuous apparatus may be very profitably employed, but it is very seldom that a new plant installs such an apparatus, it being a common occurrence to see plants using small apparatus and running their products through two or three times to get the necessary concentration, thus increasing the fuel, labor, and depreciation costs. The continuous apparatus will take the crude wood spirits and turn out the spirit of concentration desired, all in one operation.

In the production of pure methyl alcohol, it is seldom profitable to employ continuous apparatus, since the distillate must be collected carefully between certain limits determined by boiling point, odor and miscibility with water, and must be treated with various chemical re-agents in order to remove the contaminating products. However, the use of large apparatus effects a considerable saving here. Under present conditions the manufacture of this high-grade methyl alcohol, for which there is considerable demand at high prices, offers very good opportunities, since the impure spirit obtained in the process, which amounts to 60 to 70 per cent of the crude spirit used, is available for denaturing at good prices.

Acetone.—The manufacture of acetone, extensively used as a solvent, especially in the smokeless powder and celluloid industries, is another of these refined products which may be manufactured. Acetone is manufactured from acetate of lime by dry distillation, and is extensively manufactured in this country, although the methods used in many plants are, as in the other industries, inefficient and uneconomical. Process, however, have been devised whereby a product of greater purity may be as readily produced, and offers great opportunities in this industry.

The utilization of the wood tar is a subject that is but little considered, and the majority of plants burn their tar under the retorts. This tar, however, usually contains enough creosote to make it profitable to work. This creosote is a product of indefinite composition, which is much used for producing rosolate of soda, from which sulphuric acid precipitates rosolic acid, a color much used in yellow dyeing or calico printing, and it is also an excellent germicide and disinfectant. It has been profitably extracted from wood tar and wood distilleries in Canada, where it paid to burn coal in the place of tar, and it is evident that in the United States, especially in Pennsylvania, where coal is so cheap, there should be still greater opportunities for working this material and burning coal instead. Plants for refining this tar so as to obtain this creosote, consisting of stills and columns of appropriate design, can be furnished in this country.

From this brief and incomplete outline of the industry in the United States and its possibilities, it is evident that the opportunities open to wood distillers are not as poor as they may have appeared for the last two years, but that rather a large field for profitable investment is open to progressive manufacturers.

Chemistry Exhibits of the American Exposition in Berlin, 1910.

The committee in charge of the American Exposition, to be held in Berlin from July to October, has taken note of the vast importance the chemical and allied industries bear to the trade relations between Germany, commercial Europe, and the United States, and has set aside for the use of these industries some thousand square feet of space for their exhibits.

Mr. E. H. Johnson, a prominent printing-ink manufacturer of Philadelphia; Mr. R. H. Lersner, of the firm of C. M. Childs & Company, New York; Mr. I. F. Stone, president of the Chemists' Club, of New York, and Mr. Eugene A. Widmann, secretary of the H. A. Metz Company, New York, have been asked to serve as a committee on the chemical exhibits and have accepted this invitation. Mr. Widmann, chairman of this committee, can be reached at 30 Church Street, New York City.

There is no need of drawing attention to the immense exchange of chemical and allied products between the United States, Germany, and European as well as Asiatic countries. Berlin, being the commercial center of Continental Europe, offers a very fertile field not only for the manufacturer of the general line of chemicals, but for the maker of specialties. Buyers from Russia, Norway, Sweden, Italy, Turkey and other countries, and even Asiatic countries, as China and Persia, gather in this city to obtain the larger percentage of their wants.

To the American chemical industry a chance is thus given to find new markets by exhibiting the products of their factories at the coming Berlin exposition. By making their wares known in Berlin, their name and brand reach those numerous other countries.

The exposition has the endorsement of both the American and German Governments. Mr. J. Pierpont Morgan is honorary president; Mr. David R. Francis, who was president of the Louisiana Purchase Exposition held at St. Louis, is first honorary vice-president; Mr. John Wanamaker is second vice-president; Dr. George F. Kunz is president of the advisory committee, and Mr. Herman A. Metz is chairman of the executive committee. In Germany, Prince Henry of Prussia is to act as president of the reception committee.

While going to press we are informed that the exhibition will probably be postponed to the year 1911.

A Double-Zone Gas Producer for Bituminous Coal.

At a meeting of the Mechanical Section of the Engineers' Society of Western Pennsylvania, held in Pittsburgh on Dec. 7, 1909, Mr. E. F. BULMAHN, engineer of the gas-producer department of the Westinghouse Machine Company, read a paper on their bituminous power gas producer.

There are two classes of gas producers: pressure producers and suction producers. The question of the relative economy of these two classes of producers is more a matter of design than of theory. However, considering the economy of the two as equal, the sanitary conditions attending the operation of the suction producer is enough argument in its favor.

The two foregoing classes of producers are again divided into three distinct types, viz.: updraft, downdraft and double-zone producers.

The advantages of the **updraft** producer (fuel charged at top, air introduced at bottom, gas taken off at top above the fuel bed) are the production of a gas of high heat value and complete consumption of the fixed carbon in the fuel. Its disadvantage is that a large percentage of the volatile matter in the fuel is carried off in the gas as tar.

This disadvantage is overcome in the **downdraft** producer (air introduced at the top of fuel bed and gas taken off at the bottom). By passing the volatile matter, given off during the coking of the coal, through incandescent carbon the tarry vapors are fixed into permanent gases, CH_4, H_2, and CO, producing a fixed gas free from tar. In this type of producer, however, it is impossible to completely consume the fixed carbon. The breaking up of the tarry vapors and the reduction of CO_2 to CO requires from 3 ft. to 4 ft. of incandescent fuel. The oxygen introduced on top of the fuel bed after it has traveled about 2 ft. below the top has combined with carbon to form CO_2 so

that the only carbon recovered in the fixing zone is that taken up by the CO_2 gases in reducting to CO. This results in a high carbon loss in the ash.

The **double-zone** producer is designed to embody the good features of both the updraft and downdraft producers, overcoming the production of tar and completely consuming the fixed carbon. This is accomplished by having two distinct fuel beds, one operated as a downdraft producer, to break up the volatile matter, and the other operated as an updraft producer to consume the fixed carbon, the resultant gas from each zone being taken off at the center of the producer.

The double-zone producer built by the Westinghouse Machine Company was the special subject of Mr. Bulmahn's paper. It is illustrated in Fig. 1. It consists of a top and bottom shell, interposed between which is a circular iron vaporizer, which

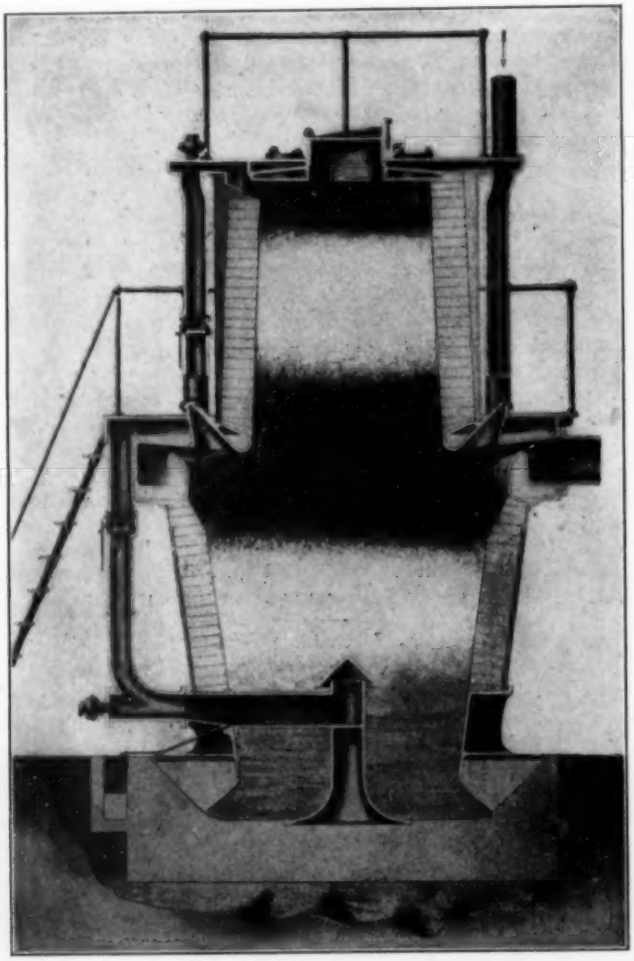


FIG. 1.—BITUMINOUS GAS PRODUCER.

furnishes steam for the producer and also serves to form the gas offtake. Air for combustion is drawn through the vaporizer, being saturated with water vapor, and is led through two pipes to the top and bottom fuel beds, the amount going to each one being regulated by two graduated cocks placed in the pipe line.

The producer is of the water-bottom design, permitting the removal of ash during continuous operation. The top of the producer is provided with a large coal-charging door, which when opened allows the operator to examine the entire top of the fuel bed. Poking is provided for by a series of poke holes through the vaporizer to take care of the bottom fuel bed, the top being poked through holes located on top and through the charging hole.

In the operation of the producer, it is filled completely with incandescent carbon. Coal is charged on top of the fuel bed and air admitted for its partial combustion. The volatile matter given off passes downward through the incandescent carbon, where it is broken up into fixed gases. The coke formed passes down through the producer, being consumed in its travel through the bottom shell, until finally reduced to ash. The gas formed in the bottom fuel bed passes upward, being taken off at the vaporizer with the gas from the top fuel bed.

From the producer the gas passes through a vertical baffled pipe, provided with a water supply for the removal of heavy impurities, to the washer (Fig. 2). The lower end of the pipe is dipped into a water seal and carries away the waste water.

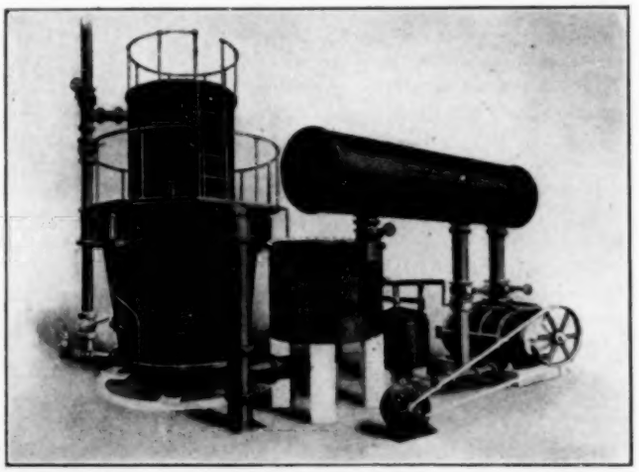


FIG. 2.—GAS PRODUCER PLANT.

The washer is a cast-iron shell, containing a series of three perforated diaphragms, immersed in water. The gas passing through the small perforations deposits its solid impurities, consisting of light ash and lampblack, and is cooled by the incoming water supply. This type of gas washer and the absence of scrubbing material makes possible the continuous cleaning of the gas and displaces the mechanically driven high-speed cleaning apparatus usually employed.

From the washer the gas passes into a cylindrical shell which is used as a mixing tank. The exhauster draws the gas from the mixing tank, maintaining a suction on the producer, and delivers the gas under pressure. When a fuel containing volatile matter is charged on an incandescent fuel bed, the gas given off during the first five minutes is highly enriched, due to the hydrocarbons given off from the volatile matter. The usual method of overcoming this variation in the gas is to provide sufficient holder capacity to equalize the quality. In the Westinghouse producer the exhauster delivers an excess quantity of gas, the excess passing into the mixing tank, where it is mixed with the lower-heat-value gas. The amount is controlled by a gasometer regulator and valve, which also serves to maintain a constant pressure in the gas outlet pipe. This gives a continuous circulation of gas through the mixer and insures an even quality of gas.

The adjoining table gives the results of a 51 weeks' continuous test of a 175-hp double-zone producer and a 15 by 14.3-cylinder gas engine. The plant was operated both 24 and 10 hours a day, the tests covering periods of from 10 to 30 days. Seven different fuels were tested as shown in the table, which gives the composition of the fuels and the economy of operation of producer and gas engine when operated with these fuels.

These tests demonstrate the adaptability of this type of producer to handle fuels, covering a wide range of heat values, and particularly the low-grade fuels. The capacity of the producer was not materially affected by any of the different fuels, except peat, with which fuel the capacity was considerably reduced.

The gas made from all the fuels was reasonably free from impurities, the solid matter averaging not more than .025 grains per cu. ft. of gas. As all the tests were made with the same engine, it afforded an excellent opportunity to note the effect of the gas on the engine. After a run of over 1000 hours, the inlet and mixing valves were removed from the engine for inspection. A slight coating of lampblack was found, but from all appearances it should have operated even a longer period without requiring cleaning.

Test No.	Kind of fuel.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur	B. T. U. per lb. as fired.	Average producer efficiency.	Combined producer and engine efficiency. Gas metered and purged out of stack.	Pounds coal per B. H. P.-hr.
1.	South American lignite	20.32	34.44	30.58	14.66	1.05	8035	76.0%	....	....
2.	Northern Colorado lignite	16.63	33.78	42.22	7.37	....	9589	78.8	16.7%	1.59%
3.	Pittsburgh run of mine	2.03	34.98	56.22	6.77	1.29	13,305	76.5	16.8	1.14
4.	Pittsburgh slack	2.27	31.86	53.91	11.96	1.76	12,689	76.0*	14.5	1.37†
5.	New England raw peat	38.10	40.54	17.86	3.50	0.19	6417	....	....	....
6.	Texas brown lignite	23.83	38.32	29.22	8.63	0.57	8007	76.7	17.5	1.82
7.	Pocahontas run of mine	1.39	16.01	74.28	8.32	0.69	13,983	80.0	16.5	1.10

* Net efficiency.
† Producer operated 10 hours a day. Fuel consumption and combined efficiency includes stand-by coal 14 hours per day.

The gas made on all the tests was of a good quality and reasonably constant in heat value. The average thermal value on bituminous coals was about 115 B.T.U., being a little higher on lignite gas. The heat value of the gas is rather low, compared with gas from an updraft producer. The reduction, however, is due to the lower H_2 and CH_4, content, a lower H_2 content being desirable for gas engine operation allowing higher compression and advanced ignition setting.

The labor required to operate the producer is comparatively small, it requiring about twenty minutes per hour of one man's time to perform all the labor on a 175-hp unit, using a Pittsburgh coking coal.

The standby loss of the producer when operating 55 hours per week represents about 0.9 per cent of the fuel when used when operating at full load.

Fig. 3 shows the producer efficiency curve, plotted from the above mentioned tests. It is particularly interesting in that it conforms to so wide a range of fuels and on account of the slight differences in the producer efficiency between one-half and full load.

The **industrial applications** of producer gas offer a wide field for gas producers. They are now quite extensively used in the manufacture of steel and glass, the producers being of the updraft type and the gas is used hot and uncleaned. There are a great many applications, however, where the gas must be distributed through small pipes, throughout a plant, and consumed in small burners, and a cool, clean gas is required. This gas may be applied to small tempering furnaces, annealing ovens, enameling kilns, hardening, blueing and baking ovens, small melting furnaces, etc. It makes a particularly inviting proposition where power is required and a portion of the gas may be used as fuel, as the labor on the producer in most cases would be the same.

Mr. Bulmahn gave in his paper diagrams showing the results of tests of a producer-gas-fired crucible furnace for melting copper billets. In one of these tests the gas and air were preheated, by utilizing the heat from the waste gases from the furnace. In the other test the gas and air were used at practically atmospheric temperature. A comparison of both tests shows the effect of preheating, in an appreciable increased economy in gas consumption, in higher furnace temperatures attained, and in the decreased amount of time required to take off a heat.

The paper elicited a very extended discussion, which is printed in full in the *Proceedings* of the Engineers' Society of Western Pennsylvania for January. In reply to several questions, Mr. Bulmahn explained that in the operation of the producer the idea is that in the top half of the producer all that is expected to be done is to coke the fuel and drive off the volatiles, the bottom working on carbon and ash only, so that the bottom fuel bed is operated as a simple updraft producer.

Finally, Mr. Bulmahn stated that with a double-zone pro-

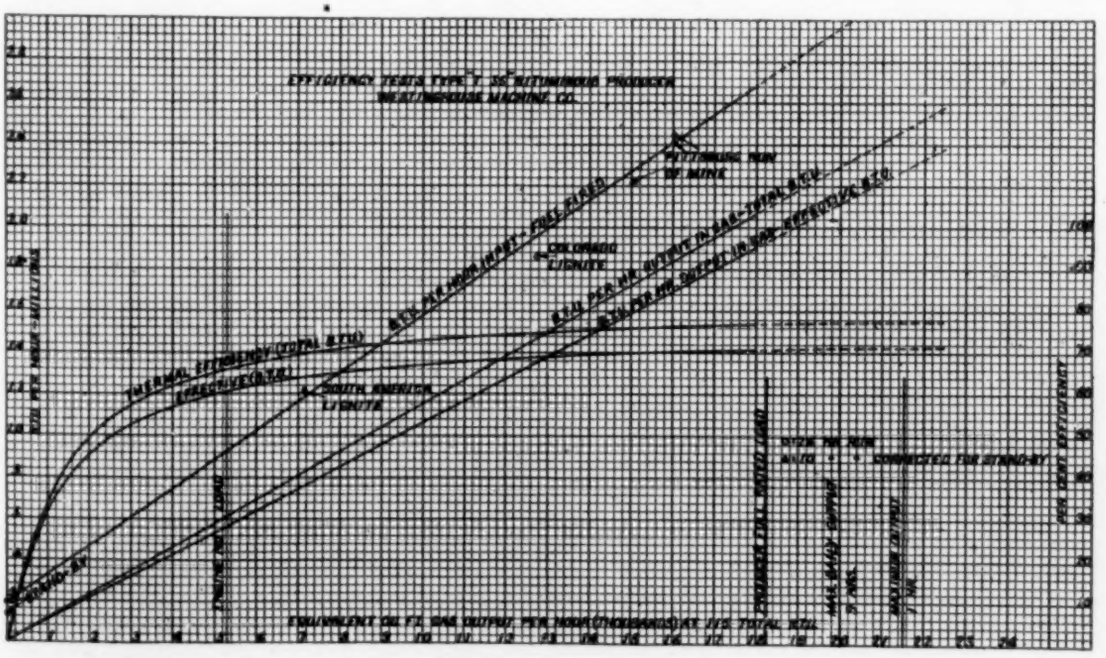


FIG. 3.—EFFICIENCY CURVE OF 175-HP BITUMINOUS GAS PRODUCER.

ducer there is less trouble from clinker than in a single-flow producer, for the reason that having two combustion zones, with practically the same area, it gives a slower rate of combustion and a slower velocity through the fuel bed. This results in lower temperatures, preventing the formation of clinkers. Some clinkers are formed when starting the producer with a cold vaporizer. These usually form about the tuyere and are easily removed from the poke holes, of which there are about eight around the circumference of the vaporizer. On intermittent operation it usually takes about 15 minutes after starting the producer before the average amount of steam is generated.

In comparing an anthracite suction producer with this double-zone bituminous producer, Mr. Bulmahn said that in the latter there are some impurities in the form of lampblack and probably the carbon content in the ash is a little higher than with an anthracite producer, which causes a slight additional loss in the efficiency of the producer. The average efficiency of an anthracite suction producer tested by him was about 80 per cent, as against 77 per cent for the bituminous. As to the practicability of the two, while the bituminous producer requires a little more labor than the anthracite, he thinks that it is to-day more reliable than the anthracite for this reason. With a fuel containing volatile matter and where one does not depend entirely on the working reaction, that is the combination of carbon and oxygen, a little irregularity in the fuel bed will not be felt as much in the bituminous as in the anthracite producer.

As a basis of comparison between natural gas, fuel oil, and fuel gas (producer when) applied to smelting or heating furnaces, the following figures were given by Mr. J. K. Lyons.

Calorific values are assumed as follows:

	British Thermal Units.
Natural gas, per cu. ft.	1,000
Fuel oil, per gallon	125,000
Fuel gas, per cu. ft. (producer)	145

The following quantities are required for one million British thermal units:

Natural gas	1,000 cu. ft.
Fuel oil	8 gallons
Fuel gas (producer)	6,900 cu. ft.

The following table gives the equivalent costs per thousand cubic feet for natural gas and per gallon for crude oil, when compared with producer gas generated from bituminous coal with recovery of sulphate of ammonia as a by-product.

It is assumed that the plant will gasify not less than 48 tons of coal per 24 hours.

Cost of Coal Per ton.	Equivalent price for natural gas per 1000 cu. ft.	Equivalent price for fuel oil per gallon.
$1.25	2.208 cts.	0.276 cts.
1.50	3.588 "	0.4485 "
2.00	6.348 "	0.7935 "
2.50	9.108 "	1.1385 "
3.00	11.868 "	1.4835 "

The above prices cover the cost of the coal and operating costs, but interest charges and depreciation and the auxiliaries are not included. If the fuel gas is used for operating internal combustion engines, the heat in the exhaust gases from the engines would be utilized in waste heat boilers, which would afford ample provision for all auxiliaries and without any addition to the operating costs.

An Efficiency Test of a Direct-Heat Dryer.

In connection with the various articles on dryer design and operations which have been published in recent numbers of this journal and which indicate that a high degree of perfection of design has now been reached on sound scientific principles, we are pleased to call attention to a short, but interesting article of Mr. W. B. Ruggles, president of the Ruggles-Coles Engineering Company, of New York, in the February issue of *Cassier's Magazine*.

Mr. Ruggles points out that while the determination of the total efficiency of the dryer using direct heat is a simple matter, it is not so easy to discover where the losses occur. There are four ways in which losses may occur—in unconsumed carbon, due to imperfect combustion; in heat carried out by the exhaust gases; in heat carried away by dried material, and in radiation from the furnace and shell.

Imperfect Combustion.—The loss due to imperfect combustion is generally ignored or rather included in the loss by radiation. However, recent tests have shown it to be a considerable factor, unless a large combustion chamber is supplied, in which space and time are given for the perfect combination of oxygen with the carbon monoxide. When the dryer is so arranged that the flames impinge directly upon a cascade of cold and wet material they are quenched suddenly and a considerable amount of carbon passes off unconsumed. This, in certain types of machines, may amount to 7 per cent or 8 per cent of the value of the fuel.

Heat in Exhaust Gases.—The heat carried away by the exhaust gases is generally the largest item of the losses and sometimes amounts to 30 per cent or more, but, as Mr. Ruggles points out, this is chiefly the case in dryers in which natural draught is used, because in this case the temperature of the stack gases is seldom below 400° Fahr., and often 600° or more. He, therefore, strongly recommends to use an exhaust fan and draw the gases against the flow of drying material, so that just before leaving the dryer it has been in contact with the cold and wet material. Undoubtedly some condensation occurs of the steam being carried out, but there is no ultimate loss, as the heat given up in condensation is absorbed by the material and aids in drying later in the process. When the current of the gases is reversed and flows in the same direction as the material, a temperature of at least 212° Fahr. must be had in the exhaust, so that no condensation may occur and moisture deposited upon the finished material.

Heat in Dried Material.—It is, of course, a matter of definition how much of the heat which is carried off by the dried material should be considered as a loss. In general, a temperature of 212° of the dried material leaving the dryer is necessary to the rapid drying of the material. But, as Mr. Ruggles points out, all heat of the material above 212° is unnecessary in most operations, and, therefore, should be charged as a loss. This is generally not great, and is, in most cases, due to imperfect operation and not to the design of the machine.

Radiation.—The radiation loss depends greatly on the design of the dryer. "In some, the shell is cool enough to place the hand on without discomfort; in others, it is not uncommon to see the shell red hot for 10 ft. or 12 ft. from the furnace. This, of course, is in a single-shell type, in which the flames impinge directly upon the shell. The loss by radiation in such a dryer is very great. In a bricked-in machine the temperature is not so high; but, as more surface is exposed, the total loss is almost as great." In general, the radiation loss is determined by difference of the total loss and of the other losses.

The following figures of a recent dryer test given by Mr. Ruggles are very instructive as the test has evidently been carried out with great care. The coal used for fuel was dried and tested calorifically. The flue gases were measured by an aerometer and analyzed for CO, and the material tested for moisture and specific heat. The figures are given in round numbers.

It will be seen that the very high efficiency of 85.8 per cent of the dryer under test was found.

Amount of coal burned per hour	400 lb.
Amount of moisture in coal	10 per cent
Calorific value of dry coal	13,000 B.t.u.
MATERIAL DRIED—BANK SAND.	
Amount of wet material per hour	45,000 lb.
Amount of dried material per hour	42,750 lb.
Specific heat of sand	.21
Moisture in sand	5 per cent
Temperature of air, sand and coal	60° F.
Temperature of dry sand	224° F.
Total moisture in coal	40 lb.
Total heat per pound of water 60° to steam	1,122 B.t.u.
Heat required to evaporate water in coal...40 × 1122 =	44,880 B.t.u.
Total heat in dry coal...360 × 13000 =	4,680,000 B.t.u.
Total heat for drying...4680000 — 44880 =	4,635,120 B.t.u.
Specific heat required to heat sand 60° to 212°, 42750 × .21 × 152 =	1,364,580 B.t.u.
Total water in sand	2,250 lb.
Total heat required to raise temperature of moisture and evaporate same...2250 × 1122 =	2,524,500 B.t.u.
Theoretical heat required	3,889,080 B.t.u.
Efficiency of dryer $\frac{3889080}{4635120}$ =	85.8 per cent
Total losses in dryer	14.2 per cent
Excess temperature of sand	12°
Loss by same...42750 × .21 × 12 =	117,730 B.t.u.
Percentage $\frac{117730}{4635120}$ =	2.5 per cent
Quantity of air exhausted @ 100° per hour	450,000 cu. ft.
Weight of air exhausted @ 100° per hour	31,905 lb.
Loss by excess temperature...100° — 60° =	40°
Specific heat of air	0.2374
Loss in exhaust air...31905 × 40 × .2374 =	302,960 B.t.u.
Percentage $\frac{302960}{4635120}$ =	6.5 per cent
Amount of CO in exhaust gases per hour	3.4 lb.
Value of CO as fuel, per pound	10,100 B.t.u.
Total loss...10100 × 3.4 =	34,340 B.t.u.
Percentage $\frac{34340}{4635120}$ =	.7 per cent
RECAPITULATION.	
Loss by excess temperature of sand	2.5 per cent
Loss by heat of exhaust gases	6.5 per cent
Loss by imperfect combustion	.7 per cent
Loss by radiation and other causes	4.5 per cent
Dryer efficiency	85.8 per cent
	100.0 per cent

This test thus shows the surprisingly high efficiency of 85.8 per cent, which is explained by the fact that the dryer under test had almost perfect combustion, very low exhaust temperature, and that the average temperature of furnace and shell was not over 150° Fahr.

Moler Bricks

So much interest has been attracted by the article on moler bricks, published in our November issue, 1909, that we add here some further details for which we are obliged to the manufacturers, Frederiksholms Tegl- & Kalkvaerker, Copenhagen, Denmark. They are making the bricks for partitions, ceilings, etc., in sizes up to 240 mm by 240 mm by 150 mm size (9½ in. by 9½ in. by 6 in.). Particulars of the composition of the "molar" earth are given in the following chemical analysis, viz.:

Silica	67.8 per cent
Alumina	6.7 " "
Iron oxide	5.5 " "
Lime	1.2 " "
Magnesia	0.9 " "
Carbonic acid	Trace
Sulphuric acid	0.6 per cent
Loss by heating	7.4 " "
Hygroscopic water	8.3 " "
Alkalies (by difference)	1.6 " "
	100.0 per cent

The weight of a moler brick of Danish normal size, 230 mm x 110 mm x 55 mm, is about 1.30 kg, while an ordinary brick weighs about 2.50 kg.

The specific gravity of a moler brick is about unity. Pressure tests of a moler brick made on June 11, 1909, showed an average strength of 156 kg per square centimeter.

Moler brick can be supplied in all European sizes, both solid and perforated. Special moler bricks are made for ceilings, arches, partitions, etc. On account of their extreme lightness, combined with unusual strength, the moler brick is recommended for partitions, ceilings, arches, etc., and, further, owing to their insulating properties, it is specially suitable for bricking steam boilers (but not to take the place of firebrick), for inner walls of hot rooms and for cooling stores, etc. They cannot be used as outside bricks on account of their porosity. Moler bricks possess special deafening qualities and are greatly to be preferred to plaster for partitions.

The following special tests of moler bricks were made by the Royal Danish Bureau for Testing Materials:

In a fire test made at one of the Copenhagen municipal gas works, it was proved that moler bricks could withstand a temperature of 1100° C. without the stability of the wall being affected.

An insulation test was made in the following manner: Three testing chambers were built close to each other above the furnaces. One of moler bricks with lime mortar, one of common bricks with lime mortar, and one of Glenboig firebrick in fireproof mortar, silica brick (fireproof) in fireproof mortar, and Kulmit brick (fireproof) in fireproof mortar. Each of the testing chambers was 18 in. square.

The test was continued for three weeks. The temperature at the surface of the furnace was 164° C. to 170° C.; in the upmost layer of moler bricks it was 63° C.; in the upmost layers of the other insulating refractories it ranged from 73° C. to 74° C., showing a difference in favor of moler bricks during the whole period of the test of at least 10° C.

Precious Metals in Colorado.

The precious metal production in Colorado for the year of 1909 was valued at $42,575,878. It is distributed as follows:

Metal and amount.	Value.
Gold, 1,303,713 oz. at $20.67	$29,949,803
Silver, 11,614,500 oz. at 51.5 cents	5,981,461
Lead, 34,023 tons at $85.60	2,912,289
Copper, 12,829,561 lb. at 13 cents	1,667,843
Spelter, 24,262 tons at $107.20	2,600,920
Chemicals from Colorado ores	1,701,562
Tungsten, 1100 tons at $360	396,000
Vanadium, 120,000 lb. at $2.50	300,000
Uranium, Gilpin County	35,000
Manganiferous iron-silver ores	15,000
Pyritic iron-silver ores	16,000
Total	$42,575,878

The total increase over the 1908 products is $9,292,867, distributed as follows: Gold, $4,254,227; silver, $1,006,033; lead, $426,618; spelter, $806,317, and copper, $284,110.

The Vinson Walsh research fund has stimulated the search for pitchblende ores throughout the State of Colorado. The output of radioactive ores has doubled. Ores of vanadium and uranium, including carnotite, are found in the Gilpin, San Miguel and Ouray districts. The hunt is being directed by the Colorado School of Mines at Golden.

Boulder County leads the United States in the production of tungsten with a total of $396,000 against a total of $135,000 in 1908. The 1907 production was $550,000. The 1908 market was against production. Since the first of last July, however, an improvement in quotations started output at a rate that may make the 1910 product $1,000,000 in view of the $7 per unit price. The average price last year was $6 a unit for the 60 per cent fine material, or $360 a ton. The Primos mill of the Primos Mining and Milling Company received $200,000 of the total paid for tungsten. This mill will have a competitor in 1910 buying and shipping concentrates.

Colorado dividends in 1909 show totals as follows: Gold mines and placers, $6,403,853; gold-silver mines, $1,946,500; silver-lead mines, $740,000; gold-lead mines, $75,000; silver mines, $100,000; gold-tungsten mines, $125,000; total, $9,390,353.

The total record of seven smelting companies treating Colo-

rado ores in 1909 was $24,124,953. Some of these treated zinc only, but most of them treated three, and some all five metals —gold, silver, lead, copper and zinc.

The chlorination mills in the State are credited with a production valued at $12,589,874. The only amalgamation mill, the Tom Boy, at Telluride, produced $487,486. The output of the cyanide mills was worth $1,614,072.

The figures given are from the report of the State geologist of Colorado.

Oxy-Acetylene Cutting.

An interesting application of the oxy-oxy-acetylene torch for cutting metal is shown in the adjoining pictures illustrating the use of this process by the American Oxygen Company of Philadelphia for cutting holes thirteen feet in circumference in the steel piling of the new permanent intake well for

FIG. 1.—CUTTING WITH OXY-ACETYLENE TORCH.

the new Chester Water Supply system, for the city of Chester, Pa.

The holes were cut in the bottom of the well after the piling was driven into place, and were for the admission of the water conduits.

The web of the piling is ⅜ in. thick, while the male ends were 2 in. thick by 2 in. wide.

Those familiar with the use of pneumatic tools will readily see that cutting such holes as these by that method would have been a slow, difficult, and expensive operation, particularly as it would have been necessary to cut the male ends with a hack saw. The cutting in this instance was easily accomplished with the standard portable plant of the American Oxygen Company, the operation requiring only minutes, where hours would have been consumed in accomplishing the same results with compressed air tools and saws.

This is only one of the many instances where the oxy-acetylene process has proved itself a valuable factor in construction work. It is stated that the great expense of cutting such passages with air tools and by hand was formerly a very serious argument against installations of this nature. As this difficulty has now been overcome by the oxy-acetylene process, it will be readily seen that the field for steel piling installations will be greatly enlarged.

Swedish Titaniferous Iron Ores.

Concerning the deposits of titaniferous iron ores in Sweden, Consul-General E. D. Winslow, of Stockholm, in a recent report, furnishes the following information: The largest deposit of titaniferous iron ore in the middle of Sweden is Taberg, in the Province of Smaland, seven miles south of the town of Jonkoping. This small mountain is 450 ft. high and consists entirely of this iron ore. The area is figured to be 2,800,000 sq. ft.

The ore is called magnetite olivinite, being at the same time a species of hyperite, holding a comparatively small percentage of iron, which is generally not higher than 32 per cent in the purer sections, and sometimes only reaches 21 per cent. There are besides some smaller veins of rich ore, holding up to 60 per cent of iron, but these veins have only a thickness of about 3 in. The proportion of titanic acid is about 4 to 8 per cent. The presence of phosphorus is 0.055 to 0.10 per cent.

The largest deposits of titaniferous iron ore on the northern parts of Sweden are Ruotivare and Vallatj, situated 10 miles northwest of Kvikkjokk Church, in the Province of Norrbotten. The distance to the nearest harbor on the Norwegian coast is 68 miles over rocky mountains, and the distance to Jokkmokk, in Sweden, is about the same, mostly over navigable lakes and streams. A new addition to the State railway of Sweden, now under construction, will connect Jokkmokk.

The ore at Ruotivare consists of a mixture of titaniferous magnetite, ilmenite, spinelle and olivine. The area has been figured at 3,240,000 sq. ft.

Gold and Silver in 1908.

According to the joint report of the United States Geological Survey and the Bureau of the Mint the production of gold in this country during the calendar year 1908 amounted to 4,574,340 fine ounces, which represents a value of $94,560,000.

FIG. 2.—STEEL PILING.

The figures show an increase of 199,513 fine ounces, or $64,124,300 over the preceding year. The production of silver was 52,440,800 fine ounces and was valued at $28,050,600, this being a shrinkage from the 1907 figures of 4,073,900 fine ounces, or $9,249,900.

In addition the production of home smelters and refineries handling foreign ore, matte, and unrefined bullion, was as follows: Gold, 892,138 fine ounces, or $18,442,100; silver, 65,107,220 fine ounces, or $34,506,800. This supply was de-

rived chiefly from Mexico, Canada, South America, Central America, Korea, and Japan.

In the native production of gold, among the States and Territories, Colorado led with a total value of $22,871,000, while Alaska and California were close behind, credited with over $19,000,000 each.

The year's increase in gold production was thought to be due, in one degree, to the closing of many mines in the base-metal camps. A tendency toward increased production among small operators was noted. Large numbers of miners left the districts in which the output of lead, copper and zinc was curtailed and turned to placer work or took up leases in the gold camps. This depression in the base-metal industries did not otherwise affect the gold production, for the total contribution from the source amounts to but 7 per cent of the normal gold output.

Placer gold made 28 per cent of the whole production, and gold from siliceous ores amounted to 65 per cent. The base-metal ores, in spite of an exceptionally heavy tonnage, gave but 7 per cent. This shows that it is futile to look for a heavily increased production of gold from a stimulated activity in these ores.

Notes.

American Electrochemical Society.—The date of the annual meeting to be held in Pittsburgh has been changed at the request of the local committee. The meeting will not be held in the last week of April, but on May 5, 6, 7. The local committee has already outlined a very attractive program.

New York Section American Electrochemical Society.—A meeting will be held on March 16 in the Chemists Club. Dr. Backeland will address the section on the Eighth International Congress of Applied Chemistry to be held in this country in 1912. Dr. F. ZIMMERMANN, of Newark, N. J., will present a paper on the Decomposition of Carbon Monoxide at Certain Temperatures in the Presence of Various Catalytic Agents. Dr. R. Stevenson of the College of the City of New York will read a paper on Electrode Reactions.

The South African Institute of Electrical Engineers.—The only society connected with the electrical profession in South Africa—has recently been formed and with the promises of support already extended to it, a membership of over 500 is shortly anticipated. Mr. Fred. Rowland, 9 Transvaal University College Building, Johannesburg, Transvaal, is the secretary.

The Susquehanna Smelting Company has decided to close its electric furnace plant for the manufacture of ferro-silicon in Lockport, N. Y., on account of the continued unsatisfactory condition of the ferrosilicon market and difficulties in regard to obtaining an extension of lease for its present plant, which is owned by the Holly Manufacturing Company, of Buffalo. Ferrosilicon is now manufactured on a large scale in this country by the Electro Metallurgical Company (with works in Kanawha Falls, W. Va., and Niagara Falls, N. Y.). A Canadian company is operating at Welland. Metallic silicon is made by the Carborundum Company.

The Mexican Institute of Mining and Metallurgy.—The regular monthly meeting of this organization was held at the School of Engineers in the City of Mexico. The members of the Institute came by reason of a special invitation from the director of the school, and they made a complete inspection of the principal departments.

Nickel in Canada.—The Mines and Minerals Committee of the Canadian House of Commons has taken up an investigation regarding the nickel resources of the country and the condition of the trade in that metal. It has been thought that the high price at which nickel is held has unduly limited the development of the immense deposits which are available.

Preliminary Mint Report for 1909.—The production of both gold and silver by the mines of the United States increased in the calendar year 1909, according to the preliminary estimates made by A. Platt Andrew, Director of the Mint. These figures show the gold product to have been $99,232,200, against $94,560,000 for 1908; silver, 53,849,000 fine ounces, an increase of 1,408,200 fine ounces. At the average price of silver—$0.52016 a fine ounce for the year—the commercial value of the silver product for 1909 would be $28,010,000.

Large Gold Export.—A recent government report showed that the year 1909 witnessed the outflow of $132,880,000 gold from the United States. This is an unexampled record. In 1904 there was shipped $121,211,000, and in 1895 $104,967,000; no other year on the record approaches 1909. The actual balance of exports over imports last year was $88,793,000; in 1904 it was only $36,408,000, and in 1895 $70,571,000.

Montana Copper in 1909.—In spite of the low prices prevailing for copper the yield of the Montana mines for last year is placed by William Walsh, State mine inspector, at a figure slightly in excess of the preceding year. Mr. Walsh estimates the output of the State for 1909 as follows: Copper, $46,000,000; gold, $4,000,000; silver, $8,500,000; lead, $2,000,000; total, $60,500,000. From every district in the State come reports of renewed activity, and this is especially true of the Butte, Corbin, Helena, Saltese, Jardine, Basin, Zortman, Boulder, Dillon, Clinton and Libby districts.

Mexican Mineral Products.—Following is a résumé of the total values of the nine products for 1909, according to the report of the Minister of Finance to the Mexican Congress: Gold, $45,014,954; silver, $77,109,742; copper, $20,383,000; lead, $6,397,000; zinc, $1,043,000; iron, $1,200,000; other metals, $2,052,158; coal, $4,400,000; mineral oil, $2,800,000; total, $160,399,854.

Petroleum.—The world's production of petroleum in 1908, as given by the *Chemiker Zeitung*, amounted to 38,052,233 tons. In 1907 35,032,235 tons were produced. There was thus a material increase. The production in tons for the two years itemized by countries is given below. The United States is credited with an output about three times as great as that of any other country:

Country.	1908.	1907.
United States	23,942,997	22,149,862
Canada	70,400	105,200
Mexico	464,188	133,855
Peru	134,824	8,732
Russia	8,291,526	8,247,795
Dutch India	1,143,243	1,116,946
Galicia	1,754,022	1,175,974
Roumania	1,147,727	1,129,097
British India	672,938	579,346
Japan	276,124	268,129
Germany	141,900	106,379

India's Mineral Production.—A summary of the mineral production of India for 1908, which appeared in a recent issue of the official *Indian Trade Journal*, states that the total value of the minerals reported in that year was $38,074,254, as against $34,354,400 in 1907. The heavy output of coal contributed the principal share to the increase, but there was also an increase in gold, petroleum, salt, saltpeter, jadestone, graphite and magnesite. On the other hand, there was a reduced output of manganese ore, mica, ruby, tin, iron ore, chromite and diamonds.

European Zinc Combine.—Referring to a report regarding the European zinc trust, Consul H. Albert Johnson, of Liége (Belgium), says that it appears that the various zinc concerns making up the trust are arranged in two principal groups. The first group comprises 18 concerns, principally the zinc works of Upper Silesia and Westphalia, certain Austrian concerns, and several Belgian works. This group is organized as a German company. In Silesia the Heritier George Van Geische Company has remained outside the syndicate, although in many ways closely associated with it. The production of the first group has been limited for 1909 to 255,086 metric tons (280,595 short tons) and for 1910 to 264,232 metric tons (290,655 short tons). The second group comprises the zinc works mainly located in Belgium, notably the Vieille Montagne Company. The production of this group is limited to 174,519 metric tons (191,971 short tons) for 1909 and to 175,919 metric tons (193,511 short tons) for 1910.

Metallurgy in Norway.—By action of the general meeting of the Meraker-Gruben Company, the works of that concern were closed the middle of December, the reason assigned being the poor condition of the ore market. One of the principal owners was the Frankfurter-Metall-Gesellschaft. This company bought the mines 40 years ago and invested 2,500,000 kroner therein. The Erjes Nickelwerk have increased their capitalization to allow an enlargement of the works.

Geological Survey Changes.—Owing to the recent resignation of Professor H. K. Barrows, of the Massachusetts Institute of Technology, as district engineer of the Geological Survey for New England and New York, a rearrangement of district chiefs has been made. Mr. C. C. Covert will be in charge of New York, Mr. Cyrus C. Babb will direct the work in Maine, while Mr. T. N. Norcross will be district engineer for the remaining New England States.

Lin Sheshun has taken formal possession of the standards of weights and measures which the Chinese Government ordered last spring from the International Office of Weights and Measures, in Paris, for the purpose of introducing the metric system in China, in conformity with a law promulgated in 1908.

Aluminium Castings.—The Valley Foundry Company of Canal Dover, Ohio, has recently been organized for the manufacture of aluminium and probably brass castings.

Addition to Foundry.—The Commonwealth Steel Company, at St. Louis, Mo., is completing an addition of its foundry which will increase the capacity about 40 per cent.

Pressure and Vacuum Gauges form the subject of a booklet published by the Schaeffer & Budenberg Manufacturing Company, of New York City. Indicating instruments for measuring pressure, temperature and speed are dealt with in the first part, while the second part is given over to recording gauges of various types.

Centrifuges.—A new catalog just issued by the International Instrument Company describes the centrifuges manufactured by that concern. The machines are electrically operated, being built in combination with motors. Several of the chemical ends enumerated to which the machines can be put are to dry crystals for rapid production of chemically pure salts, to hasten settling of precipitates and thus avoid oxidation, to extract rapidly essences of compounds from drugs, and to refine sugar. The centrifuges vary in sizes, many being very moderate in price. Accessories are listed in the latter part of the booklet.

Slow-Speed Chilian Mills.—In the fourth edition of their catalog, which was recently issued, the Lane Slow-Speed Chilian Mill Company, of Los Angeles, Cal., print a general article on the use and operation of slow-speed mills. Following this come a detailed description of the company's product, a series of letters from actual operators, and a department of tables and other useful information.

Lava.—The material known as "Lava" and familiar to most people on account of its very universal use in gas tips and burners, is the subject of an instructive booklet issued by the American Lava Company, of Chattanooga, Tenn. The substance is not, as might be inferred, of natural volcanic origin, but is the mineral talc $H_2Mg_3Si_4O_{12}$. It is machined while soft in its natural state and through subsequent baking at a temperature of about 2000° Fahr. it attains its familiar hardness.

Gas-Burning Appliances.—An interesting bound volume of bulletins relating to gas-burning appliances has been recently issued by the Improved Appliance Company, of Denver, Colo. Besides listing the burners and ovens manufactured by the concern, it contains as well much useful data, including tables of melting points of various substances, heating values of gases, boiling points, cubic feet of gases to the pound, approximate water capacity and specific heats. There are also notes on the properties and uses of gases.

Coal Briquetting Machinery.—From the Mashek Engineering Company, of 90 West Street, New York City, comes an extremely well-arranged catalog describing plants and machinery, together with a brief discussion of processes and cost of manufacture. In a section dealing with the possibility of briquetting without binders, it is stated that there is no coal in the United States that can be handled in this way and give a commercially successful article. It is also said that the expenses of plants operating without the use of coal-tar pitch are higher than those of plants briquetting the same fuel with the use of the pitch binder.

The Toledo Electric Welder Company moved its offices from Toledo to Cincinnati on Feb. 4 and is now located in a new factory at Knowlton and Langland streets, Northside, Cincinnati, Ohio. The building is fully equipped with the best and most modern tools necessary for the building of their line of welding machines, the entire plant being motor driven. A 75-kw, single-phase, alternating-current generator supplies the power for testing the welding machines up to their full rated capacity. The shops are lighted by a motor-driven direct-current generator and mercury lights are largely in evidence. A night force will be put on at once to take care of the deliveries promised.

Leadite Melting Furnace.—A folder describing a furnace just devised for melting leadite has been issued by the Leadite Company, Land Title Building, Philadelphia, Pa. The furnace has been designed with special regard to safety, and as it uses gasoline for fuel, it saves much time in pipe jointing work when compared with a charcoal-burning furnace. It will melt 50 lb. of leadite or 325 lb. of lead.

Bleachery.—The Cluett, Peabody Company of Troy, N. Y., are planning to erect, at Cohoes, N. Y., a bleachery to work in conjunction with the shirt and collar manufacture.

The Metallic Purification Company is planning to erect a plant at Chattanooga, Tenn., which will cost approximately $1,000,000 and will employ 1,500 men. It is stated that the principal outputs of the plant will be alum and aluminium. The by-products will depend on the chemical analysis of the clays used. The information so far obtainable is meagre.

The American Oxygen Company of Philadelphia, Pa., was wrongly stated in an article in our last issue to be the successors of the American Ferrofix Brazing Company. The American Ferrofix Brazing Company is still in existence and the American Oxygen Company has no connection with it whatever.

Mines Census.—The Geological Survey and the Census Bureau have entered into a joint arrangement by which the Survey is relieved of the collection of statistics of the annual production of minerals for the year 1909. That work is, by the agreement, merged in the Census Bureau's activities under the Thirteenth Census act, which requires a census of mines and quarries for 1909. Consequently, the Survey will not this year send its own schedules directly to the mine and quarry operators. The Census Bureau's general and supplementary schedules relative to this branch of its decennial work include the inquiries in which the Survey is interested and such other data as may be necessary for the latter's reports will be furnished the Survey by the Census Bureau. The schedules will be collected by the Census special agents and enumerators. The co-operative arrangement was in recognition of the necessity of uniformity in the compilation of the statistics, the elimination of duplicate work and inquiries, and the desirability of economy in the collection of the required data.

The Dorr Cyanide Machinery Company has been incorporated with J. V. N. Dorr as president and offices at 728 Equitable Building, Denver, Colo. This was made necessary by the increasing business in Dorr classifiers and Dorr continuous thickeners, and incidentally permits Mr. Dorr to devote more time to his professional work as metallurgical engineer. An interesting application of the Dorr classifiers and Dorr pulp thickeners is noticed in an article in this issue on a silver cyanide plant in Mexico.

Electrical Mining Equipment.—A publication of interest to electrical engineers engaged in mining has recently been

issued by Crompton & Company, Salisbury House, London, E. C. It contains about 50 illustrations of plants and apparatus typical of the methods used in the supply and utilization of electricity in mines, a subject to which, as demonstrated by the extensive list of mines in which Crompton machinery is used, the company has given considerable attention.

Iron and Steel Activity in France.—Great activity is noted in the iron and steel manufacturing districts in France. This is due in a large measure to the placing of orders for 1000 cars for the state railroads and 2300 cars for the Paris-Lyons Railroad.

National Association of Cement Users.—The annual convention of this association has been held at Chicago, Ill., February 21-25, 1910. In addition to the regular committee reports and topical discussions a list of papers of general interest will be presented.

Carnegie Relief Fund.—The relief fund created by Andrew Carnegie for employees of the Carnegie Steel Company disbursed $200,545 in accident and death benefits and pension allowances in 1909, which is about $10,000 less than the amount paid out the previous year. This makes a total of $1,540,086 disbursed since the relief fund was instituted in 1902.

Iron Production and Consumption.—"The most distinctive feature in the iron trade of the world in the past year," the London *Statist* declares, "has been the marked contrast between the activity in the United States and the lethargy in this country. In truth, the consuming capacity of the American furnaces beyond the American sources of supply of the mineral presents one of the problems of the trade—or presents it again in a vivid form, for it is not a new one—namely, the future supply of the world's iron."

Cement Companies Merged.—By a merger filed with the New Jersey Secretary of State, on Jan. 22, the Cement Manufacturing Company, with a capital stock of $2,000,000, was absorbed by the Alpha Portland Cement Company, which has works in Warren County. The Alpha Company had a capital stock of $6,000,000, of which $2,000,000 was outstanding. The capital stock of the consolidated corporation is $10,000,000, divided into $8,000,000 common and $2,000,000 preferred, the latter bearing 7 per cent cumulative dividends. The officers of the new concern are: President, Arnold F. Gerstell, Easton, Pa.; vice-president, John M. Lockhart, Pittsburgh, Pa., and secretary-treasurer, Gabriel S. Brown, Easton, Pa.

New Engine Ordered.—The Sapulpa (Oklahoma) Steel & Iron Mills have recently placed an order with the Allis-Chalmers company for a 28-in. x 48-in. non-condensing, heavy-duty rolling-mill engine.

New Mining Equipment.—The mining engineering laboratories at the Massachusetts Institute of Technology have recently installed an Allis-Chalmers feeder and a Richards pulsator jig for experiments on ore concentration. This latter apparatus was invented by Prof. Robert H. Richards last year and it has proved of great value. In the mining department the following changes in assistants were made for the current scholastic year: F. Jaeger succeeds L. A. Dickinson; T. G. Chapman succeeds L. D. W. Bender; H. R. Batcheller succeeds C. A. Gibbons, and E. T. Almy has been appointed.

Water Turbines.—The Dayton-Globe Iron Works Company, of Dayton, Ohio, have recently issued catalogs on their "New American Turbine" for the development of water power. The turbines are of the reaction type, vertical or horizontal, and according to requirements are furnished with either balanced flutter, wicket or cylinder gates. Two classes of wheels are made: those for low head from three to fifty feet, diameters from ten to sixty inches, and outputs up to 2363 hp; and those for a high head of fifty to two hundred feet. The largest turbine listed operates with a two hundred foot head and a seventy-two inch wheel and delivers 6784 hp at a speed of 179 to 238 r.p.m. and a discharge of 22,380 cu. ft. per minute. Head gate hoists and gearing work for the wheels, also beating and washing engines and wood pulp grinders are included in the output of this company. The increasing hydroelectric installations among the mining and metallurgical plants of the West present a large field for water turbine equipment.

Salt Industry in Italy.—In Italy the salt industry is entirely in the hands of the government, it being a monopoly utilized as a means of taxation for raising revenue. The importation or production of salt by private individuals is prohibited, and it is sold to the public only in special shops where postage stamps and tobacco are offered for sale. All the salt produced in Italy comes from sea water, evaporated at the works on the islands of Sardinia and Sicily, and at Volterra in the Province of Pisa. The government both imports and exports salt. In 1907 the imports were 51,604 and the exports 99,191 tons. In 1908 the imports were 42,610 and the exports 85,489 tons. Salt was exported to the United States to the amount of 15,590 tons in 1907 and 7,871 tons in 1908.

Glass Manufactory to Rebuild.—The Muncie (Ind.) Glass Manufacturing Company has decided to rebuild its works, recently destroyed by fire, at an estimated cost of $70,000.

Transite Asbestos Wood.—A booklet describing one of their products, "Transite Asbestos Wood," has been issued by the H. W. Johns-Manville Company, of New York City. This material is mineral in character, being made from asbestos fiber and binding cements. It has the same physical characteristics as ordinary wood, except that it is harder and takes a higher polish. Among the advantages urged for this product are its adaptability to manipulation by means of wood-working tools, its fiber strength under transverse loads of 3500 lb., and its absolutely fireproof qualities, it having withstood the most severe tests by fire without being warped, distorted, or weakened in any way. The manufacturers specially recommend its use for flooring, sheathing, partitions, fire doors, fireproof cabinets and gages. A special form of the product, called "Ebony Asbestos Wood," is made to combine high electrical insulating capacity with its fireproof properties. It is somewhat similar in structure to the regular product, but it is saturated with a special insulating compound. When finished it resembles ebony. For example, it may be used for switchboards, panel boards, switch and fuse bases, insulating barriers, duct linings, car-floor linings, electric heater insulation, and rheostat tops.

Personal.

Mr. **F. A. S. Andrew** has joined the firm of E. A. Herbert & Company, Ltd., of London, England, as a director. He will supervise particularly the departments dealing with spiegeleisen, ferro-manganese, ferrosilicon, silico-speigel and other alloys, together with manganese, manganiferous iron and other ores. For the past 20 years Mr. Andrew has been associated with the Pyle & Blaina Works, Ltd.

Mr. **W. G. Bringham** has been appointed manager of the new tin plate plant of the Phillips Sheet & Tin Plate Company, at Weirton, W. Va. He was formerly manager of the American Sheet & Tin Plate Company.

Mr. **Fred H. Daniels** has been decorated by King Gustav of Sweden with the Cross of Knighthood of the Northern Star in recognition for courtesies extended to Swedish engineers in this country. Mr. Daniels is chief engineer and a director of the American Steel & Wire Company.

Mr. **A. E. Drucker** has been appointed consulting metallurgist of the Oriental Consolidated Mining Company in Korea.

Mr. **William E. Ellis** has left for Mexico and has again taken charge of the Guebeshe Mill at Ocotlan, Oaxaca, Mexico.

Mr. **W. Spencer Hutchinson** is arranging for the installation by the Vulture Mines Company of a cyanide plant designed by Mr. S. V. N. Dorr.

Mr. **J. P. Jennings**, district superintendent of the Pennsylvania Coal Company, has been chosen president of the Scranton Mining Institute for the ensuing year.

Mr. **Robert Kann,** consulting chemist to the Raritan Copper Works, Perth Amboy, N. J., has opened at 24 Cliff Street, New York City, a commercial laboratory, making a specialty of metallurgical analysis and research.

Mr. **Julian Kennedy** has been appointed engineer to supervise the erection at Buffalo of a new blast-furnace plant for the Rogers-Brown Iron Company.

Dr. **C. Offerhaus,** known to many of our readers through his connection during the past few years with several metallurgical companies of this country and with Columbia University, is now connected as metallurgical engineer with Messrs. Paul Schmidt & Desgraz, Prinzenstrasse 1a, Hannover, Germany.

Mr. **Leopold Salazer** has been appointed secretary of the Mexican Institute of Mining and Metallurgy to fill the vacancy caused by the resignation of Mr. Kirby Thomas.

Mr. **T. I. Stephenson** has been elected president of the Knoxville (Tenn.) Iron Company, succeeding Mr. W. B. Chamberlain, resigned.

Mr. **Thomas R. Stevens** has accepted a position with the Caucausus Copper Company, of Batum, Russia.

Mr. **R. K. Stockwell,** who has recently been with the Steptoe Valley Smelting & Refining Company, in the position of smelter engineer, has resigned that position and is now construction engineer for the United States Smelting, Refining & Mining Company. At the present time he is stationed at Eureka, Utah.

Mr. **Albert L. Waters** has completed successfully the installation of the new pyritic smelter at Mollen, Colo., six miles north of Denver.

M. **André Weill,** of Paris, has been inspecting a number of water-power sites in the vicinity of Ottawa, Canada, in the interests of the Creuzot Steel Company. This is thought to have to do with the contemplated erection of an electric iron-ore reduction and steel-refining plant near Ottawa.

Obituary.

Mr. **James W. Fuller,** president of the Lehigh Car, Wheel & Axle Works, died in Catasauqua, Pa., on Jan. 15.

Mr. **Fayette Brown,** president of the Brown Hoisting Machinery Company, died on January 20, at his home in Cleveland, Ohio. Mr. Brown was born at Bloomfield, Ohio, in 1823. In 1880, with his two sons, Harvey H. and Alexander E. Brown, he organized the Brown Hoisting and Conveying Company, which has since been reorganized, becoming the Brown Hoisting Machinery Company. At the time of his death Mr. Brown was chairman of the Stewart Iron Company and president of the Union Steel Scale Company and the International Chemical Company.

Digest of Electrochemical U. S. Patents.

Prior to 1903.

Arranged according to subject matters and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

Electric Furnaces (*Continued*).

No. 652,640, June 26, 1900, Henry N. Potter, Goettingen, Germany.

Resistance type, for forming tubular Nernst-lamp glowers, etc. The chamber and resistor is a tube composed of a mixture of dry electrolytes, e.g., magnesia and yttria, or zirconia and yttria, ground and mixed with paste, tragacanth or starch, and water, to form a dough. Around this tube is a jacket consisting of one of the constituents of the tube, e.g., magnesia or yttria, or some other material inert or non-injurious to the tube, e.g., thoria. The jacket is baked on the tube in a porcelain kiln. Then a heating-conductor is wound about the furnace, or about a tube of insulating material, talcite, surrounding the furnace. Platinum terminal wires are attached to the ends of the inner resistor tube. The composite tube is heated by gas to such temperature that the inner tube carries current. Upon the first electrical heating both tube and jacket crack. The cracks are filled with a paste of similar material. Several such patchings may be necessary. The jacket serves as a non-fluxing support for the cracked inner tube, having small electrical conductivity. The wire winding serves in use to bring the tube resistor to the temperature requisite to cause it to act as a solid electrolyte and heating resistor.

654,463, July 24, 1900, Henri Leleux, of Paris, France.

"Resistance" type. A furnace especially for the production of calcium carbide, comprising a pot mounted on a carriage or suspended from traveling pulleys, constituting the lower electrode, and an upper electrode adjustably depending from a fixed support. The pot has a flat hearth of carbon blocks and metal sides and casing. The hearth is partially subdivided by a horizontal insulating layer of non-conducting concrete, to concentrate the resistance-heating action of the electric current, passing upward from the metal bed-plate beneath, to the front portion of the hearth, near the tap hole. The metal casing automatically makes contact with an electric main when the pot is moved into place. The pot is surrounded on three sides by walls having openings and passages leading to a chimney, causing a down draught of cool air around the pot. The depending upper electrode consists of four square carbon bars or cores, spaced apart and imbedded in a coked mass of crushed carbon and tar, protecting the cores from air. The resistance of the coked mass is comparatively high, largely restricting the heating effect of the current to the cores. The electrode is cooled by the current of air passing downward around the pot. The upper electrode is adjustably supported by a chain and is connected to two sets of cable-mains. Contact with the cores is made by thin copper plates, which may be silvered, compressed against the inner faces of the upper ends of the carbon cores by wedges and screws.

654,467, July 24, 1900, James Mactear, of London, England.

Resistance furnace, for heating a mass of wood charcoal or other catalytic substance. The heated mass is employed to convert a mixture of ammonia and carbon monoxide into ammonium cyanide. The furnace chamber is oblong and has sides of porcelain, closed at the top and bottom by removable horizontal plates. Inlet and outlet gas mains lead through these plates. The chamber is heated by a series of platinum resistance-coils, wound on vertical refractory rods and mounted in refractory tubes depending from the cover of the chamber, giving a uniform temperature throughout the charcoal.

655,779, Aug. 14, 1900, William Smith Horry, of New York, N. Y.

A uniform current at constant voltage is maintained by moving the furnace electrodes relatively to each other or to the furnace chamber, which may be fixed or movable. The furnace shown is of the Horry wheel type, two electrodes of opposite polarity depending into the wheel receptacle at one side. The wheel is rotated by a gear on its shaft, driven by a worm and electric motor. A two-phase motor is shown, which may be driven in either direction by two switches, employing mercury cups. Pins which enter these cups are carried by a tilting lever. Gravity normally tilts the lever to make contact with one set of mercury cups. As the current in the furnace mains increases, it acts through a transformer surrounding one main and a solenoid energized thereby to tilt the lever and close the other mercury cups, reversing the motor and moving the wheel receptacle in such direction as to decrease the current. The current from the transformer may actuate the motor switches through an electro-magnetic relay, instead of directly. The motor may be direct current, or a steam, air or hydraulic engine may be used.

655,780, Aug. 14, 1900, William Smith Horry, of New York, N. Y.

A modification of the preceding furnace-control mechanism. A slow, even movement of the current-regulating element of the furnace is undesirable, causing the mixture in the furnace to form an arch which delays response to the regulation. The improved mechanism is intended to give the regulating element a quick, jerky movement, causing the mixture to fall at once into the zone of reduction. The mechanism shown is a long bar, extending past a number of furnaces of the Horry wheel type, and continuously reciprocated. Connected to the bar at each furnace is a vertical pivoted lever, the upper end of which carries two pawls, faced in opposite directions and respectively engaging two ratchet-wheels on a shaft geared to the furnace. The pawls are weighted to normally remain out of engagement with the ratchet-wheel, but a solenoid is arranged to magnetize each pawl and cause it to engage. The solenoids are respectively energized by switches electro-magnetically controlled by the furnace current, as in the preceding patent.

656,600, Aug. 21, 1900, R. Doolittle, of Chicago, Ill.

Arc type. The furnace used for manufacturing calcium carbide in accordance with the process of patent 656,599. The furnace is a tall, narrow stack, having a hopper and feed-screw at its upper end. Burners for gas or oil open into the top of the chamber. Superposed pairs of opposed electrodes pass through the side walls of the stack, near its middle. A gas-exhaust pipe leads from the lower part of the stack. A removable receptacle closes the lower end of the stack and receives the carbide; or the carbide may be tapped out. In a modification, the lower end of the stack is surrounded by a cooling jacket or coil, and air is injected into the bottom of the stack to cool and granulate the carbide. Grates are shown to subdivide the carbide into small streams as it flows downward to the blast.

656,930, Aug. 28, 1900, Wilhelm Borchers, of Aix-la-Chapelle, Germany.

Arc or resistance type, especially for the manufacture of calcium carbide. The furnace is a vertical or inclined stack having a hopper at its upper end and opposed electrodes passing through its sides. The lower portion of the stack is surrounded by a water-jacket, cooling the product below 400° C. The jacket may be used as a steam boiler for running an engine. The contents of the furnace are gradually removed at the lower end, allowing the pig or carbide to descend. Portions are then broken off by chisels, passing through openings in the walls. In the inclined type of furnace, a toothed roller extends through the lower end, engaging and pulling the carbide downward. Surrounding the feed-hopper is a gas outlet chamber containing peat carried on a perforated bottom, which acts to filter the escaping gases and prevent their carrying away combustible dust.

(*To be continued.*)

BOOK REVIEWS.

A Text Book of Ore Dressing. By **Robert H. Richards, S.B., LL.D.,** assisted by **E. S. Bardwell** and **E. G. Goodwin.** 702 pages, 374 illustrations. Price, $5 net. New York: McGraw-Hill Book Company.

Our German masters in technology have an expressive term whose exact equivalent does not exist in English. They distinguish the "Lehrbuch" from the "Handbuch"; the former is the *teaching* book, the latter the *reference* book. Professor Richards has made this separation in the realm which he has made almost his private domain. His Ore Dressing is inimitable, unmatched in its thoroughness, but for that very reason unsuitable for teaching the subject. Messrs. Bardwell and Goodwin have condensed the matter from the larger four-volume work on Ore Dressing, and did the actual writing of this book to which Professor Richards contributed only the general outline, and the storehouse from which all the material was extracted.

Ore Dressing is mostly a concentrating operation, to render the valuable material more available and to facilitate its extraction and utilization. We may therefore say that one of the most useful contributions which Professor Richards has made to this subject, comparable perhaps to anything else he has accomplished in actual value to the profession, is the operation by which, with a concentration ratio of 4 to 1, the present volume has been extracted from its immediate predecessors and progenitors. The result is a "concentrate" whose value to students, teachers, learners, laborers, and masters in this field is almost inestimable. Its completeness and accuracy disarm criticism. Its parts are splendidly balanced, the treatment is equable and judicial, and altogether it is a "Lehrbuch" in the best sense and quality of that word.

* * *

Welding and Cutting Metals by the aid of Gases or Electricity. By Dr. **L. A. Groth,** Consulting Engineer. Cloth, 281 pages, and many illustrations. Price $3.00. D. Van Nostrand Company, New York, 1909.

This work contains a full account of the various processes mentioned in the title, particularly as practiced abroad. There are introductory notes on the gases employed and descriptions of the apparatus for using them are very detailed. A comparison is drawn between the oxy-hydrogen and oxy-acetylene methods, and the burners or blow-pipes suitable for each are illustrated and the construction shown. The welding of aluminium is given a special chapter. In this no mention is made of Mary W. Emme, who secured a U. S. patent for welding this metal, antedating Heræus.

The Goldschmidt aluminothermic welding process is accorded a considerable space. Particular attention is paid to electrical welding devices, those of Thomson being prominent, and numerous illustrations are given of the apparatus used. The subject of welding marine boilers forms a chapter by itself, as also the cutting of metals by the blow-pipe. There is a chapter on reports of the efficacy of acetylene welding, and a final chapter on legislation.

The work is attractive and well printed. The style, while interfered with by many extracts from reports and trade descriptions, has a slightly foreign tinge.

* * *

Solid Bitumens. Their Physical and Chemical Properties and Chemical Analysis, Together with a Treatise on the Chemical Technology of Bituminous Pavements. By **S. F. Peckham,** A. M., Chemist to the Department of Finance, City of New York. 8vo, 324 pages, 29 illustrations. Price, $5. New York and Chicago: Myron C. Clark Publishing Company.

A praiseworthy attempt to bring order out of confusion in a very dark corner of chemical technology.

Part I (89 pages) deals with the natural history of the bitumens, their history, distribution, derivation and classification.

Part II (172 pages) is the principal portion of this book, dealing with the chemistry of the bitumens, in eight chapters. The principal topics are the methods of ultimate analysis, proximate analysis, technical analysis, special tests, and the testing of auxiliary substances, such as street mixtures, cements, concretes. A person who knows little of the subject will find here a great store of information, carefully and systematically collated; the expert who knows almost all about the subject will doubtless find the presentation valuable for reference and discover some original ideas contributed by the author.

Part IV (19 pages) deals rather too briefly with the physical properties of the bitumens. In our comparative ignorance we had thought the physical properties would have been given nearly as extensive a consideration as the chemical properties;

certainly a larger part of the usefulness of the bitumens finds its basis in their characteristic physical properties.

Part V (38 pages) is a brief presentation of the chemical technology of bituminous streets, and is considerably below the level of the rest of the book. This subject is handled so well in Dr. Clifford Richardson's "The Modern Asphalt Pavement" that Mr. Peckham would have saved himself trouble and ended his book more fittingly by simply giving this reference, and not have run the risk of spoiling the good impression made by the rest of his book.

While the author's style is here and there stiff and his treatment at times controversial, yet his writing is almost always interesting and his arguments instructive, even when they fail of being convincing.

* * *

Beet Sugar Making and its Chemical Control. By **Y. Nikaido,** B.Sc., M.A. Cloth. Price, $3. Easton, Pa.: Chemical Publishing Company; and London, England: Williams and Northgate.

In the preface of this book it is stated that "the aim of this work is to aid those who are starting their career in the beet sugar manufacture, but lack systematic training in the technique thereof."

The preface likewise offers a list of references used by the author in the preparation of the book. These are, many of them, of elementary character, such as should be available either in a private or public library to any one, who would venture to enter the beet sugar industry either as employer or employee. The industry requires trained men, and has little tendency toward the training of men from the start. Our chief criticism of the book is that it contains so much that is elementary and inadequate to the accomplishment of the purpose intended.

The first four chapters might well be eliminated and this is also largely true of Chapter V.

For young employees in the laboratory, inexperienced in beet-sugar analysis, which is possibly the class referred to by the author in his preface, the descriptions of the apparatus and analytical methods in Chapters VI to IX inclusive, will be of some use, and they will be useful also to the laboratory director because it will obviate the necessity for much elementary instruction. Otherwise the work seems of doubtful value.

The book is well made, excellently printed and bound, contains a good table of contents and list of illustrations, and a well prepared index, the latter so often wanting in technical works.

The book also contains six tables which may prove useful in some laboratories, but which in presence of the valuable books of Kent, Spencer, Biedermann, Stammer, Stohmann, and Classen, which should form part of the equipment of the laboratory of every beet-sugar works, are entirely superfluous and need not have been copied.

* * *

A Course of Qualitative Chemical Analysis of Inorganic Substances, with explanatory notes, by **Olin Freeman Tower,** Ph.D., 83 pages. Price, $1. Philadelphia: P. Blakiston's Sons and Company.

In the opening paragraph of the preface of this book the author properly remarks "Some apology is necessary for the appearance of another text-book of Qualitative Analysis." And he further properly remarks "most of the briefer treatises on this subject are entirely inadequate in the treatment of the subject from the modern standpoint and in lack of precautionary directions which are necessary to secure delicacy of practice."

What the author says is intensely true. Most of the "briefer courses" of qualitative analysis are mere "short cuts" to success, and in this class of work as in every other the short cut to success generally ends in failure.

This should not be true, by any means, of the work before us. It is up to date in every respect. It is practically an application of the modern theories and laws of physical chemistry to chemical analysis, and it is entirely new.

In the introduction are discussed briefly dissociation, ionization, reversible reactions, reactions between ions, equilibrium and the solubility product, hydrolysis, amphoteric electrolytes, the electro-motive series and oxidation and reduction; briefly, the chief principles of physical chemistry.

Then follows "Directions for Laboratory Work" in application of the principles set forth and described in the introduction. These begin with "basic" analyses or, in less modern parlance, properties of and tests for bases and the separation and detection of these substances, followed by sections or chapters on "acid" analysis and dry substances.

In the basic analysis the grouping of the elements is but slightly different from that adopted in the older text-books on the subject.

The seven groups of the author are as follows: Silver Group, Copper-Tin Group, Iron Group, Zinc Group, Calcium Group, Magnesium Group and Potassium Group.

In the discussion of the several groups in basic analysis the author treats each one in the following order, preliminary tests, precipitation, notes on precipitation, analysis and notes on analysis.

In the Tin Group the author adds a brief chapter on interfering substances and notes thereon.

In acid analysis he establishes three classes: the sulphuric acid group, the halogen group, and the nitric acid group; and in this division he follows a method of treatment somewhat different from that used in the basic division. He makes two brief chapters, the first on preliminary tests, and the second on speed tests.

The preliminary tests seem to show the presence or absence of ammonium and sodium, and the condition of reduction of the compounds of iron and of the tin salts which may be present.

A page of notes following the preliminary tests calls attention to precautions to be observed and oversights which may occur, as well as reactions which may be produced in the operations and which may affect the ultimate result.

Following the matter on preliminary tests are chapters devoted to the separation of each of the groups respectively and the analysis of the group separated, and each separation and analysis is accompanied by a page of notes relating to the procedure. This arrangement of the systematic analysis is novel, but it seems effective and should serve well in laboratory works.

A brief chapter is likewise devoted to analysis in the dry way, corresponding with the usual course of blowpipe analysis.

The book proper closes with a chapter on the preparation of solutions, and here the author offers instruction in the preparation of solutions and of solid substances for examination; first for basic analysis, and second for the acid analysis.

An appendix is added giving a table of reagents in solution, showing specific gravity of the solution, concentration per cent, and approximate normal concentration. A few paragraphs on special methods for preparing certain solutions, which will prove useful in every laboratory, a table of degree of dissociation of electrolytes, and a series of optional methods for treatment of the several groups respectively, are also added.

On the front cover lining is a table of atomic weights of the principal elements and on the back cover lining is a solubility table. The book is also of convenient form and size for use on the laboratory table.

The book is well worthy of the considerate attention of instructors in qualitative analysis and will doubtless find a place in many of the laboratories of instruction throughout the country.